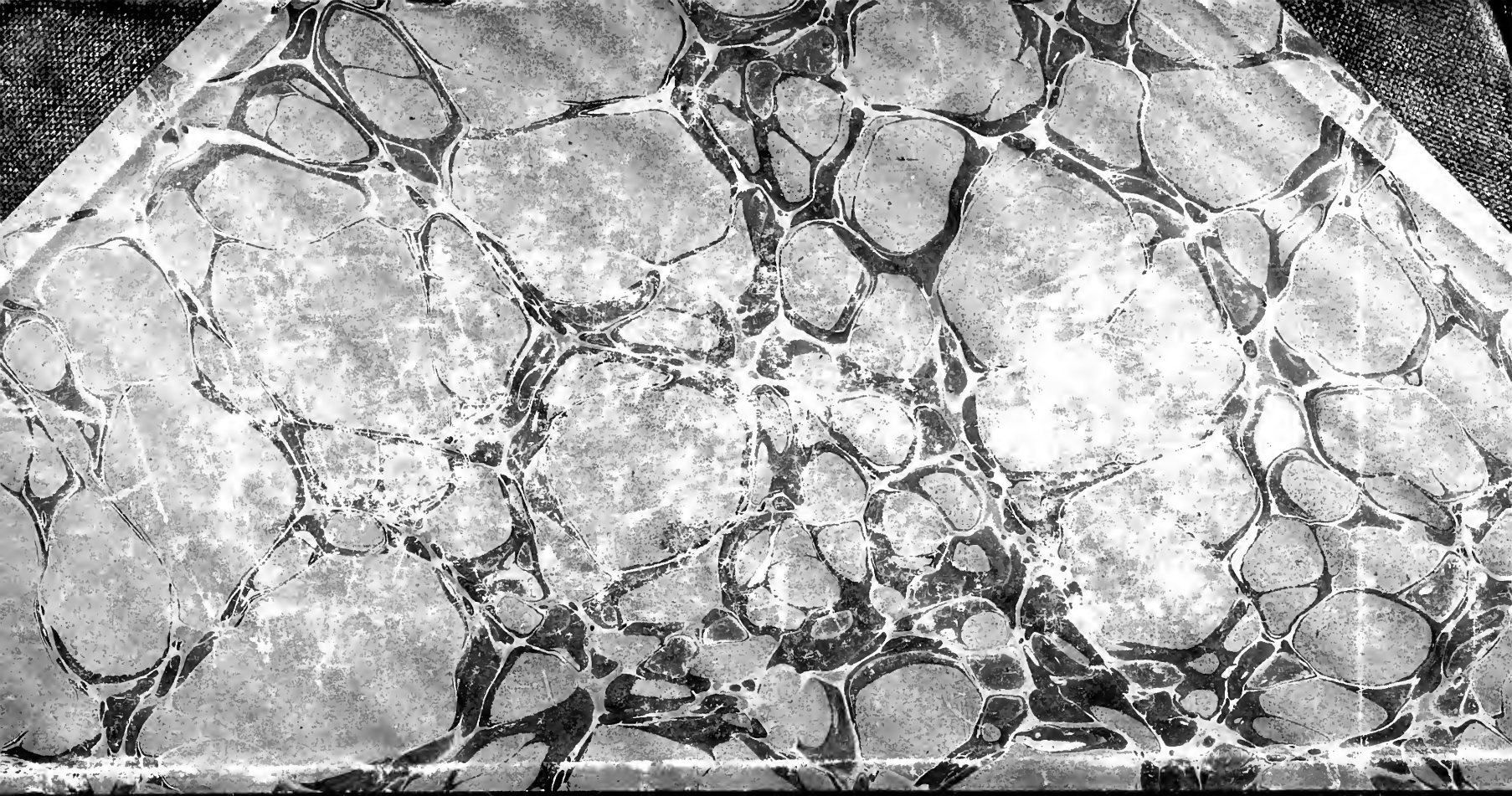

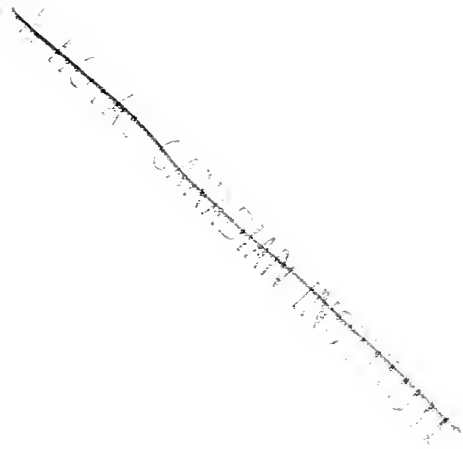

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THE NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

TRANSACTIONS.

VOL. LVII.

1906-1907.

EDITED BY THE SECRETARY.

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12 . 4 . 57

CONTENTS OF VOL. LVII.

PAGE.

ADVERTIZEMENT ii
CONTENTS iii

GENERAL MEETINGS.

1906. PAGE.

Aug. 1.—General Meeting, to receive the Members of the American Institute of Mining Engineers (Newcastle-upon-Tyne) ... 1
Visits to Works, etc.:—
Dawdon Colliery 2
Horden Colliery 4
Aug. 4.—Annual General Meeting (Newcastle-upon-Tyne) 6
Election of Officers, 1906-1907 6
Annual Report of the Council, 1905-1906 7
Annual Report of the Finance Committee... 10
Representatives on the Council of The Institution of Mining Engineers, 1906-1907 11
Accounts 12
G. C. Greenwell Medals 17
"An Appliance for Automatically Stopping and Restarting Mine-wagons." By W. Galloway 19
Discussion 22
"Deposits in a Pit-fall at Tanfield Lea, Tantobie, County Durham." By J. A. Smythe 24
Electro-barograph for Mines 29
Sept. 10.—Excursion Meeting of Associates and Students (Bowburn Winning) 31
"Bowburn Winning." By A. L. Steavenson 31
Oct. 13.—General Meeting (Newcastle-upon-Tyne) 35
Death of Mr. John Daglish 35
Discussion of Mr. W. Archer's paper on "Improved Dampers for Coke-oven Flues" 37
Discussion of Mr. Sam Mavor's paper on "Practical Problems of Machine-mining" 37
"The Valuation of Mineral Properties." By T. A. O'Donahue 45
Discussion 63
Dec. 5.—Excursion Meeting (Swalwell)... 66
Electric Plant, Axwell Park Colliery... 66
Dec. 8.—General Meeting (Newcastle-upon-Tyne) 69
Discussion of Dr. J. A. Smythe's paper on "Deposits in a Pit-fall at Tanfield Lea, Tantobie, County Durham" 70
Discussion of Mr. W. Maurice's paper on "A Rateau Exhaust-steam-driven Three-phase Haulage Plant" 71

1906.

Dec. 8.—General Meeting (Newcastle-upon-Tyne).—*Continued.* PAGE.

"Experiments Illustrative of the Inflammability of Mixtures of Coal-dust and Air." By P. Phillips Bedson and Henry Widdas 73

Discussion 75

"Liquid Air and its Use in Rescue-apparatus." By Otto Simonis 78

Discussion 83

"Sinking through Magnesian Limestone and Yellow Sand by the Freezing-process at Dawdon Colliery, near Seaham Harbour, County Durham." By E. Seymour Wood ... 95

Discussion 121

1907.

Feb. 9.—General Meeting (Newcastle-upon-Tyne) 123

Discussion of Mr. Otto Simonis' paper on "Liquid Air and its Use in Rescue-apparatus" 124

"Ferro-concrete and its Applications." By T. J. Gueritte ... 132

April 13.—General Meeting (Newcastle-upon-Tyne) 147

Discussion of Mr. W. E. Garforth's paper on "A New Apparatus for Rescue-work in Mines" 148

Discussion on the Explosion at Wingate Grange Colliery ... 151

Discussion of Mr. E. Seymour Wood's paper on "Sinking through Magnesian Limestone and Yellow Sand by the Freezing-process at Dawdon Colliery, near Seaham Harbour, County Durham" 165

"Sliding-trough Conveyors." By M. Malplat 166

Discussion 168

"Memoir of the late John Daglish." By M. Walton Brown ... 169

June 8.—General Meeting (Newcastle-upon-Tyne) 173

Discussion of Mr. R. Cremer's paper on "The Pneumatogen: The Self-generating Rescue-apparatus, compared with other Types" 174

Discussion of Mr. E. Seymour Wood's paper on "Sinking through Magnesian Limestone and Yellow Sand by the Freezing-process at Dawdon Colliery, near Seaham Harbour, County Durham" 175

"Treatment of Dust in Mines, Aboveground and Belowground." By Richard Harle 178

Discussion 181

June 6.—Excursion Meeting (Sunderland) 185

C Pit, Monkwearmouth 185

"Memoir of Sir Lowthian Bell, Bart." 187

APPENDICES.

I.—Notes of Papers on the Working of Mines, Metallurgy, etc., from the Transactions of Colonial and Foreign Societies and Colonial and Foreign Publications 1-100

"Cutaneous Infectivity of Ankylostomiasis." By Gino Pieri... 1

"Mining Legislation in Holland." By J. G. Bousquet 1

"Underground Temperatures in the Pas-de-Calais, France." By Félix Leprince-Ringuet 2

APPENDICES. – *Continued.*

I. – Notes of Papers, etc. – *Continued.* PAGE.

"Seasonable Distribution of Earth-tremors". –
(1) By F. de Montessus de Ballore 3
(2) By F. de Montessus de Ballore 3
"Earth-tremors in Greece during the Years 1900 to 1903." By D. Eginitis 4
"Earthquake of 1905 in Calabria, Italy":—
(1) By Mario Baratta 5
(2) By G. Mercalli 5
"Earthquake in Finland, 1902." By J. E. Rosberg 6
"Chilian Earthquake of August, 1906." By Hans Steffen ... 7
"Earthquakes of 1906 at Masaya, Nicaragua." By Karl Sapper 9
"Cyperaceæ and the Accumulation of Alluvial Gold." By H. Jumelle and H. Perrier de la Bathie 10
"Humus and the Formation of Bog- and Lake-ores." By Ossian Aschan 11
"Manganiferous Bog-ore and the Formation of Manganese-deposits." By J. H. L. Vogt 12
"Origin and Age of Metalliferous Ores." By Alfred Ditte ... 14
"Diffusion-theory of the Origin of Ore-deposits." By G. B. Trener 15
"Formation of Iron-ore Deposits and their Classification." By O. Stutzer 16
"Magmatic Segregation of Iron-ores in Granite." By J. H. L. Vogt 17
"Genesis of Oolitic Iron-ores." By Stanislas Meunier ... 18
"Stratigraphical Conditions affecting the Occurrence of Petroleum." By A. F. Stahl 19
"Tertiary Coal-depo-its of Ruda, Dalmatia." By F. von Kerner 20
"Carboniferous Marine Strata in Hungary." By Fritz Frech 21
"Petroleum-bearing Rocks of Komarnik-Mikova and Luh, Hungary." By Julius Noth 22
"Petroleum- and Ozokerite-deposits of Boryslaw, Galicia." By J. Grzybowski 23
"Pyritic Deposits of Kazanesd, Hungary." By Anton Lackner 24
"Copper-ores and Wolfram-ores in Southern Tyrol." By J. Block 25
"Formation of the Belgian Coal-measures." By A. Renier ... 26
"A Marine Band in the Charleroi Coal-measures, Belgium." By René Cambier 28
"Fauna and Flora of the Lower Coal-measures of Baudour, Hainaut":—
(1) By J. Cornet 28
(2) By Armand Renier 29
"Lower Division of the Liége Coal-measures." By P. Fourmarier 29
"Marine Bands in the Upper Coal-measures of Mons, Belgium." By J. Cornet 30
"Campine Coal-field, Belgium." By H. Forir, A. Habets and M. Lohest 30

APPENDICES.—*Continued.*

I.—Notes of Papers, etc. *Continued.* PAGE.

"Manganiferous Iron-ores of Lienne, Belgium." By Joseph Libert ... 33
"Coal-basins of Carmaux-Albi, France." By Jules Laromiguière ... 34
"Coal-field of French Lorraine":—
(1) By Jules Bergeron and Paul Weiss ... 35
(2) By R. Zeiller ... 35
(3) By J. Bergeron ... 36
"Unsuccessful Borings for Coal in Picardy, France." By J. Gosselet ... 37
"Shear-planes in the St. Étienne Coal-field, France." By G. Friedel and P. Termier ... 37
"Iron-ore derived from Glauconite, Ardennes, France." By L. Cayeux ... 38
"Magnetic Iron-ore of Diélette, Lower Normandy." By L. Cayeux ... 39
"Auriferous Stibnite of Martigné, Britanny." By O. Stutzer 39
"Gold and Silver in the Trias of French Lorraine." By Francis Laur ... 40
"Metalliferous Deposits of the Val de Villé, Alsace." By — Ungemach ... 41
"Asphaltic Limestones of the Gard, France." By P. Nicou... 42
"Phosphatic Deposits of France." By O. Tietze ... 44
"Aix-la-Chapelle Coal-field, Germany." By H. Westermann ... 45
"Recent Bore-holes and Sinkings in the Rhenish-Westphalian Coal-field." By P. Krusch ... 47
"Brown-coal Deposits of Upper Lausitz, Silesia." By Kurt Priemel ... 49
"*Posidonia Becheri* in Upper Silesian Coal-measures." By R. Michael ... 51
"Asphalt-deposit at Mettenheim, Hesse." By A. Steuer ... 51
"Kaolin-deposits of Halle-an-der-Saale, Saxony." By Ewald Wüst ... 52
"Nickeliferous Magnetic Pyrites of the Black Forest, Baden." By E. Weinschenk ... 53
"Stanniferous Deposits of the Fichtelgebirge, Bavaria." By Albert Schmidt ... 55
"Holzappel Metalliferous Belt, Hesse-Nassau." By G. Einecke 56
"Pyrites-deposits of the Western Erzgebirge, Saxony." By Otto Mann ... 56
"Tungsten-ore deposits in Saxony." By R. Beck ... 58
"Graphite-deposits in the Piedmontese Alps." By Vittorio Novarese ... 59
"Azurite-deposit of the Castello di Bonvei, Sardinia." By F. Millosevich ... 61
"Tungsten-ores in the Cagliari District, Sardinia." By Domenico Lovisato ... 62
"Metalliferous deposits of North-eastern Sicily." By B. Loti 63
"Blende- and Galena-deposits of Traag, Norway." By J. H. L. Vogt ... 65

APPENDICES.—*Continued.*

I.—Notes of Papers, etc.—*Continued.* PAGE.

"Gellivaara and Kiirunavaara Iron-ores, Northern Sweden":—
(1) By O. Stutzer 66
(2) By O. Stutzer 68
(3) By O. Stutzer 68
"Graphite-deposits in Lapland." By O. Stutzer 69
"Auriferous deposits of Finnish Lapland." By Curt Fircks ... 69
"Manganiferous and other Ore-deposits of Nizhne-Tagilsk, Russia":—
(1) By N. Yakovlev 71
(2) By A. Krasnopolsky 71
"Auriferous deposits of Servia." By Douchan Jovanovitch ... 71
"Mercury Ore-deposits of Avala Hill, Servia." By H. Fischer 73
"Ore-deposits of the Province of Almeria, Spain":—
(1) By O. Pütz 75
(2) By Baron F. Fircks 77
(3) By Baron F. Fircks 78
"Huelva Pyrites-deposits, Spain." By Bruno Wetzig 80
"Argentiferous Galena of Cadlimo, Switzerland." By E. Mariani 83
"Mineral-resources of Asia Minor":—
(1) By Fr. Freise 84
(2) By C. Schmeisser 85
"Coal-bearing Beds of Fushun, Southern Manchuria." By J. Palibin 88
"Mineral Resources of Korea." By — Berteaux 88
"Coal-bearing Beds in the Kuznetsk District, Siberia." By B. K. Polienov 89
"Gold-bearing Regions of Siberia":—
(1) By E. Ahnert 90
(2) By A. Gerasimoff and P. I. Preobrazhensky ... 90
(3) By E. Ahnert, M. M. Ivanoff, A. Khlaponin, P. Rippas and P. Yavorovsky 90
(4) By A. Khlaponin 90
(5) By Ernst Maier 92
"Mineral Resources of the Chukchen Peninsula, Eastern Siberia." By J. Korsuchin 95
"Copper, Tin and Gold in Katanga, Congo Free State":—
(1) By H. Buttgenbach 97
(2) By H. Buttgenbach 98
(3) By H. Buttgenbach 99

II.—Barometer, Thermometer, etc., Readings for the Year 1906. By Percy Strzelecki 101-110

III.—Annual Report of the Council and Accounts for the Year 1906-1907; List of Council, Officers and Members for the Year 1907-1908; the Charter and Bye-laws; etc. ... ... i-lxxxiv

APPENDICES. *Continued.*

PAGE.

IV.—Miners' Eight-hours Day Committee: Evidence by Mr. J. H. Merivale on behalf of The North of England Institute of Mining and Mechanical Engineers ... ... lxxxv-lxxxviii

V.—Memoir of George Henry Evans lxxxix

INDEX 1-11

LIST OF PLATES:—

	PAGE.		PAGE.
PORTRAIT OF MR. JOHN DAGLISH	*Frontispiece*	IX., X.	120
		XI.	180
I.	22	XII. ... (Appendix II.)	110
II.	34	XIII. ... (Appendix II.)	110
III., IV., V., VI., VII., VIII.	120	I. ... (Appendix IV.)	lxxxviii

JOHN DAGLISH.

PRESIDENT OF THE NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS, 1884-1886.

Born on June 26th, 1828, and died on August 9th, 1906.

THE NORTH OF ENGLAND INSTITUTE

OF

MINING AND MECHANICAL ENGINEERS.

GENERAL MEETING,

TO RECEIVE THE MEMBERS OF

THE AMERICAN INSTITUTE OF MINING ENGINEERS,

HELD IN THE WOOD MEMORIAL HALL, NEWCASTLE-UPON-TYNE,

AUGUST 1ST, 1906.

The LORD MAYOR (Sir Joseph Baxter Ellis) extended to the members of the American Institute of Mining Engineers a most hearty and kindly welcome, not only to England but to the Metropolis of the North. He need not say how highly they appreciated the visit of so important an institute to the heart of the iron-and-steel industry of England. It was interesting to know that when visiting Middlesbrough they had seen the great works and the immense progress that had been made; but that great and wonderful industry of Tees-side owed much of its prosperity to Newcastle-upon-Tyne and to the men who had gone there from Newcastle, many years ago, in the persons of the late Sir Lowthian Bell, Sir Hugh Bell, Mr. H. W. F. Bolckow and Mr. J. Vaughan. These men laid down what had proved to be a great industry on the banks of the Tees. He hoped that the visitors would see many things of interest, while they were in the district.

The PRESIDENT (Mr. T. W. Benson), on behalf of The North of England Institute of Mining and Mechanical Engineers, welcomed the visitors to the ancient city of Newcastle, and to the oldest coal-field in Great Britain. Early in the fourteenth

century coal was worked at Elswick by the prior and brethren of Tynemouth, and the burgesses of Newcastle worked coal near the place where they were then assembled. The appliances were primitive, and horses were used for haulage, until George Stephenson and William Hedley invented their locomotive engines. The safety-lamp was invented by Dr. William Reid Clanny and by George Stephenson, so that the district was the birthplace of many inventors who had improved the methods of mining.

Captain Robert W. Hunt (Chicago), President of the American Institute of Mining Engineers, said that the Lord Mayor was quite right when he spoke of the influence of Newcastle, and they knew it, even in America, and one of his best friends in Chicago was a Newcastle man. He did not wonder that Englishmen loved England, and the moment that one put one's foot on the shores the beauties of the land captured one. He returned thanks for the welcome that had been given them and for the hospitality which they knew they were going to receive.

The following notes record some of the features of interest seen by the visitors to the collieries, which were, by kind permission of the owners, thrown open for inspection during the course of the meeting on August 1st and 2nd, 1906:—

DAWDON COLLIERY.

Sinking operations were commenced in April, 1900, with the Castlereagh and Theresa shafts, each to be 20 feet in internal diameter and 1,800 feet deep, to the Hutton Seam.

Before reaching the Coal-measures, the Magnesian Limestone was sunk through as follows:—Surface-overburthen, 11 feet; Magnesian Limestone, 356 feet 10½ inches; Marl Slates, 3 feet 0½ inch; and Yellow Sands, 92 feet 4 inches.

Sinking was carried out through the heavily-watered ground by means of pumps capable of dealing with 7,000 gallons per minute, until the Theresa shaft had reached a depth of 350 feet, and the Castlereagh shaft a depth of 204 feet, in Magnesian Limestone; the water being then pumped amounted to 7,050 gallons per minute, or more than could be readily raised by the

pumps. It was then decided to freeze the shafts, so as to sink through the remaining thickness of Magnesian Limestone, and 92½ feet of Yellow Sands, in a frozen state, rather than erect additional pumping plant.

In April, 1903, preparatory to freezing, 28 bore-holes were sunk around each shaft, to a depth of 484 feet and 21 feet into the Coal-measures. The bore-holes were completed in April, 1904; and freezing was then commenced, and continued until February 16th, 1906. During this period both shafts were sunk through the frozen limestone and sand into the Coal-measures, and the whole of the water-bearing strata was lined with cast-iron tubbing.

The shafts are, at present, being sunk through Coal-measures. The Castlereagh shaft, at a depth of 810 feet, is passing through the "filtering post," containing a feeder of water amounting to about 100 gallons a minute, and this water is being drawn by the winding-engine. The Theresa shaft is sunk to a depth of 780 feet, into the filtering post, where a feeder of water amounting to 100 gallons a minute has been encountered; and this water is being drawn with the sinking engine, until arrangements are made to deal with it.

The total length of cast-iron tubbing in the Castlereagh shaft is 456 feet, and below this there is 108 feet of brickwork. The total length of tubbing in the Theresa shaft is 438 feet, and below this is 204 feet of brickwork.

There are two sinking-engines, each with cylinders 24 inches in diameter, and 4 feet stroke; and drums 8 feet in diameter and 6 feet wide. The locked-coil ropes are 3¾ inches in circumference.

Steam is supplied from eight Galloway boilers, 30 feet long and 8 feet in diameter, working at a pressure of 100 pounds per square inch. There are four sets of Green fuel-economizers, each fitted with 120 tubes.

There are two Archbutt-Deeley water-softeners capable of treating 60,000 gallons of water per day. The water is reduced from 16 degrees to 4 or 5 degrees of hardness by the treatment: 40 pounds of lime and 7 pounds of alkali being used for each tank of water treated, at a cost of ½d. per 1,000 gallons.

The horizontal winding-engine at the Castlereagh shaft, with two cylinders, 40 inches in diameter and 6 feet stroke, fitted with

Corliss valves, has a parallel drum, 20 feet in diameter and 10 feet wide. It is drawing water from a tank in the Castlereagh shaft. A sister-engine is being erected at the Theresa shaft.

The walls for the heapstead and screening plant are in course of erection.

HORDEN COLLIERY.

The total area of the royalties leased and owned by The Horden Collieries, Limited, is about 19,000 acres. The Shotton and Horden collieries have been opened out and developed during the past six years to work a portion of this property, and it is intended at a later period to open out and develop two more collieries at Hesleden and Castle Eden respectively. At the present time, the production averages 2,500 tons of coal per day.

The three shafts at Horden were sunk through the Magnesian Limestone, before entering the Coal-measures at a depth of about 1,050 feet. The north and south downcast shafts are 20 feet, and the east upcast shaft is 17 feet, in finished diameter.

The north shaft is sunk to the Hutton seam at a depth of 1,200 feet, the total depth of the shaft being 1,260 feet. Sinking was commenced on November 6th, 1900, and completed on July 22nd, 1904. In this shaft, water was met with at a depth of 198 feet, and from this point downwards to a depth of 522 feet, the shaft is secured with cast-iron tubbing. Above and below the tubbing the shaft is secured with brickwork, built solid, 14 inches thick. The sinking has passed through the Five-Quarter, Main Coal, Low Main and Hutton coal-seams, all of workable section.

The south shaft is sunk to a depth of 907 feet to the level of the Main coal-seam, as it is intended to work the Five-Quarter and Main coal-seams from this shaft.

The east shaft is at present completed down to the level of the Hutton seam. It is intended shortly to carry it down to the Harvey seam, at a further depth of about 120 feet.

At present, about 800 tons of coal per day are being drawn from the east pit, whilst the permanent shaft-sidings underground in the north and south pits are being completed. It is intended eventually to utilize the east pit for the conveyance of

men and materials underground, and for lifting coal from the level of the Harvey seam. The north shaft will be used for working the Hutton and Low Main seams; and the south shaft for working the Five-Quarter and Main coal-seams.

During the sinking of these shafts, continuous pumping over a period of three years was necessary, in handling from 3,000 to nearly 10,000 gallons of water per minute in passing through the Magnesian Limestone and Yellow Sands before the Coal-measures were reached.

The tandem-compound winding-engine has four cylinders, 21 inches and 36 inches in diameter by 5 feet stroke taking steam at a pressure of 160 pounds per square inch, fitted with Frew balanced slide-valves and automatic expansion-gear. The two drums on each crank-shaft are 16 feet in diameter and 5 feet wide. The locked-coil winding ropes are $1\frac{3}{4}$ inches in diameter, and the unbalanced load consists of 4 tons 4 cwts. of coal. The double-decked cages contain 4 tubs on each deck; and the tubs on the top decks are discharged by hydraulic rams simultaneously with those on the bottom deck.

The first portion of the screening plant, consisting of three main picking-belts and cross-belts for small and nut coal, is driven electrically.

The sirocco fan, driven electrically, will produce 350,000 cubic feet of air per minute, at a water-gauge of 4 inches. It has just been completed and set to work.

Visits were also made to the Hylton* and Wearmouth† collieries of the Wearmouth Coal Company, Limited; the Dunston coal-shipping staithes of the North-eastern Railway Company;‡ the north pier of the Tyne Harbour;§ the Wallsend and Walker works of Messrs. Swan, Hunter and Wigham Richardson, Limited;‖ the Elswick works of Sir W. G. Armstrong, Whitworth & Company, Limited;¶ Alnwick and Bamburgh castles; and the Roman camps, etc., at the Chesters and Housesteads.

* *Trans. Inst. M. E.*, 1904, vol. xxviii., page 149.

† *Ibid.*, page 152. ‡ *Ibid.*, page 172. § *Ibid.*, page 158.

‖ *Ibid.*, page 187. ¶ *Ibid.*, page 177.

THE NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

ANNUAL GENERAL MEETING,
HELD IN THE WOOD MEMORIAL HALL, NEWCASTLE-UPON-TYNE,
AUGUST 4TH, 1906.

MR. T. W. BENSON, RETIRING-PRESIDENT, IN THE CHAIR.

The SECRETARY read the minutes of the last General Meeting, and reported the Proceedings of the Council at their meetings on July 21st and that day, and of the Council of The Institution of Mining Engineers.

ELECTION OF OFFICERS, 1906-1907.

The CHAIRMAN (Mr. T. W. Benson) appointed Messrs. Norman B. Ridley, Arthur Mundle, Mark Ford and W. B. Wilson, junr., as scrutineers of the balloting-papers for the election of officers for the year 1906-1907.

The SCRUTINEERS afterwards reported the result of the ballot, as follows:—

PRESIDENT:

Mr. J. H. MERIVALE.

VICE-PRESIDENTS:

Mr. R. D. BAIN.	Mr. T. E. FORSTER.	Mr. HENRY PALMER.
Mr. F. COULSON.	Mr. T. Y. GREENER.	Mr. M. W. PARRINGTON.

COUNCILLORS:

Mr. R. S. ANDERSON.	Mr. C. C. LEACH.	Mr. R. F. SPENCE.
Mr. W. COCHRAN CARR.	Prof. HENRY LOUIS.	Mr. R. W. BERKLEY.
Mr. B. DODD.	Mr. W. C. MOUNTAIN.	Mr. S. HARE.
Mr. T. E. JOBLING.	Mr. J. H. NICHOLSON.	Mr. J. P. KIRKUP.
Mr. A. M. HEDLEY.	Mr. F. R. SIMPSON.	Mr. C. H. STEAVENSON.
Mr. HENRY LAWRENCE.	Mr. JOHN SIMPSON.	Mr. A. N. L. WOOD.

The CHAIRMAN (Mr. T. W. Benson) moved a vote of thanks to the Scrutineers for their services.

Mr. J. G. Weeks seconded the resolution, which was cordially adopted.

Mr. J. H. Merivale thanked the members for the honour that they had conferred upon him. He moved a vote of thanks to the Retiring-President, Vice-Presidents, Councillors and Officers for their services during the past year.

Mr. Henry Lawrence seconded the motion, which was heartily adopted.

Mr. R. S. Anderson moved a vote of thanks to the representatives of this Institute on the Council of The Institution of Mining Engineers for their services during the past year.

Mr. A. Mundle seconded the proposal, which was cordially adopted.

The Annual Report of the Council was read as follows:—

ANNUAL REPORT OF THE COUNCIL, 1905-1906.

The Council regret to have to refer to the great loss that the Institute has sustained through the death of Mr. William Logan, a vice-president of the Institute, 1902-1905, and a member since 1867.

The sad and appalling explosion which took place at the Courrières colliery, the number of lives lost exceeding that of any previous colliery disaster, is greatly to be regretted, and appreciation can only be expressed of the arduous and valuable services that were rendered by the exploring and rescue-parties.

The following table shows the progress of the membership during recent years:—

Year ending August 1st.	1900.	1903.	1906.
Honorary Members	30	26	25
Members	883	921	931
Associate Members	132	112	114
Associates	108	161	190
Students	59	69	56
Subscribers	23	23	33
Totals	1,235	1,312	1,349

Although 99 members of all classes have been added to the register during the past year, there has been a decrease of 3 members, owing to exceptional losses by death, resignations, etc.

The Library has been maintained in an efficient condition during the year: the additions, by donation, exchange and purchase, include 390 bound volumes and 47 pamphlets, reports, etc.: and the Library now contains about 10,900 volumes and 337 unbound pamphlets. A card-catalogue of the books, etc., contained in the Library renders them readily available for reference.

Members would render useful service to the profession, by presentations of books, reports, plans, etc., to the Institute, to be preserved in the Library and thereby become available for reference.

Mr. Frederick Charles Keighley of Uniontown, Fayette County, Pennsylvania, U.S.A., represented the Institute at the celebration of the two-hundredth anniversary of the birth of Benjamin Franklin, the founder of the American Philosophical Society.

G. C. Greenwell gold, silver and bronze medals may be awarded anually for approved papers "recording the results of experience of interest in mining, and especially where deductions and practical suggestions are made by the writer for the avoidance of accidents in mines."

G. C. Greenwell bronze medals have been awarded to Messrs. William Cuthbert Blackett and Robert Galen Ware for their paper upon "The Conveyor-system for Filling at the Coal-face, as practised in Great Britain and America;"* and to Mr. Donald M. D. Stuart for his paper upon "The Development of Explosives for Coal-mines."†

Prizes for books have been awarded to the writers of the following papers, communicated to the members during the year 1904-1905:—

"Observations on Water-sprayed or Damped Air in Coal-mines." By Mr. James Ashworth.

"The Mickley Conveyor." By Mr. John Wright Batey, M.I.M.E.

"The Action, Influence and Control of the Roof in Longwall Working." By Mr. James Thom Beard, M.I.M.E.

"Note on a Natural Paraffin found in the Ladysmith Pit, Whitehaven Collieries." By Mr. Roger Dodds.

* *Trans. Inst. M. E.*, 1905, vol. xxix., page 449. † *Ibid.*, page 299.

"Note on the Composition of Coal from the Faröe Islands." By Mr. Roger Dodds.

"Notes on Safety-lamp Oils." By Dr. George Percy Lishman, Assoc.M.I.M.E.

"The Miners' Worm-disease, as seen in Westphalian and Hungarian Collieries." By Dr. Thomas Oliver.

"The Action, Influence and Control of the Roof in Longwall Working." By Mr. Edward Heton Roberton.

"The Development of Explosives for Coal-mines." By Mr. Donald M. D. Stuart, M.I.M.E.

"Note on the Calorific Effect of Coal from the Faröe Islands." By Mr. R. R. Thompson.

"Note on the Composition of Dover Coal." By Mr. R. R. Thompson.

During the past year, the concluding part of the *Report of the Committee upon Mechanical Coal-cutting* was issued to the members, who are greatly indebted to the members of the Committee for this exceedingly valuable report. Mr. H. F. Bulman has received an honorarium in recognition of his services as engineer to the Committee.

A Committee has been appointed to enquire into the treatment of coal-dust in collieries, and the results of their investigations will be communicated to the members in due course.

At the instance of the Council, Prof. Henry Stroud, instructed Mr. G. C. Wood, a research-student at the Armstrong College, to make measurements of the specific electrical resistances of the different substances found in mines, and the results of these investigations, communicated by Mr. G. C. Wood, have been printed in the *Transactions*.

The papers printed in the *Transactions* during the year are as follows:—

"The Lander Anemometer."

"A Conveyor for Filling Coal at the Face." By Mr. Léon André.

"Improved Dampers for Coke-oven Flues." By Mr. William Archer, M.I.M.E.

"The Application of Direct Cementation in Shaft-sinking." By Mr. C. Dinoire.

"A Mechanical Coal-cutter in Queensland." By Mr. William Fryar.

"The Great Planes of Strain in the Absolute Roof of Mines." By Mr. Henry Wallace Gregory Halbaum, M.I.M.E.

"Corundum in Ontario, Canada: Its Occurrence, Working, Milling, Concentration and Preparation for the Market as an Abrasive." By Mr. David Gillespie Kerr, M.I.M.E.

"The Alumino-thermic Welding Process, and its Application to General Engineering." By Mr. J. Stewart MacGregor.

"The Unwatering of the Acholdu Colliery, with a Description of the Riedler Express Pump." By Mr. John Morris, M.I.M.E.

"Undersea Extensions at the Whitehaven Collieries, and the Driving of the Ladysmith Drift." By Mr. John Shanks, M.I.M.E.

"The Barton and Forcett Limestone-quarries." By Mr. Thomas Teasdale, M.I.M.E.

"Determination of the Specific Electrical Resistance of Coal, Ores, etc." By Mr. G. C. Wood.

Excursions were made to Dawdon colliery in September, 1905, and to the Elswick works of Sir W. G. Armstrong, Whitworth & Company, Limited, in June, 1906.

The Institution of Mining Engineers has now completed its seventeenth year, and the members are to be congratulated upon its continued success. Meetings have been held during the past year in Manchester in September, 1905, and in London in June, 1906.

The CHAIRMAN (Mr. T. W. Benson) moved the adoption of the Annual Report of the Council.

Mr. J. H. MERIVALE seconded the motion, which was adopted.

The Report of the Finance Committee was read as follows:—

ANNUAL REPORT OF THE FINANCE COMMITTEE.

The Finance Committee submit herewith a statement of accounts for the twelve months ending June 30th, 1906, duly audited.

The total receipts were £2,888 1s. 3d. Of this amount, £49 19s. was paid as subscriptions in advance, leaving £2,838 2s. 3d. as the ordinary income of the year, compared with £2,740 16s. in the previous year. The amount received for ordinary current-year subscriptions was £2,249 1s. and arrears £287 16s., as against £2,295 7s. and £186 6s. respectively in the year 1904-1905. *Transactions* sold realized £44 4s. 3d., as compared with £18 10s. 10d. in the earlier period, while the sum received for interest on investments was the same in both years, namely, £317 10s.

The total expenditure was £2,544 10s. 10d., that for the previous year (which included a few exceptional items) being £2,733 18s. Decreases are shewn in the expenditure for furniture and repairs, salaries and wages, postages, incidental expenses, expenses of meetings, and prizes for papers. The sum of £52 10s.

has been paid for work done in connection with the supplementary volume to *An Account of the Strata in Northumberland and Durham, as proved by Borings and Sinkings*, and £60 8s. 7d. for the fitting of panels in the Lecture Theatre.

The figures given above show that the total income exceeded the expenditure by £343 10s. 5d., and adding to this the balance of £553 9s. 1d. in hand at the beginning of the year, there is a sum of £896 19s. 6d. to carry forward.

The names of 47 persons have been struck off the membership-list in consequence of non-payment of subscriptions. The amount of subscriptions written off was £203 18s., of which £115 16s. was for sums due for the year 1905-1906, and £88 2s. for arrears. It is probable that a considerable proportion of these amounts will be recovered by the solicitors, and will be credited in future years. Of the amounts previously written off, £94 8s. was recovered during the past year.

JOHN B. SIMPSON.

August 4th, 1906.

Mr. J. H. MERIVALE moved the adoption of the Annual Report of the Finance Committee.

Mr. THOMAS DOUGLAS seconded the resolution, which was adopted.

REPRESENTATIVES ON THE COUNCIL OF THE INSTITUTION OF MINING ENGINEERS, 1906-1907.

The CHAIRMAN (Mr. T. W. Benson) moved, and Mr. George May seconded, a resolution that the following gentlemen be elected as the representatives of the Institute on the Council of The Institution of Mining Engineers for the year 1906-1907:—

Mr. R. DONALD BAIN.
Mr. BENNETT H. BROUGH.
Mr. C. S. CARNES.
Mr. W. COCHRAN CARR.
Mr. FRANK COULSON.
Mr. THOMAS DOUGLAS.
Mr. T. E. FORSTER.
Mr. J. W. FRYAR.
Mr. G. C. GREENWELL.
Mr. REGINALD GUTHRIE.
Mr. T. E. JOBLING.
Mr. AUSTIN KIRKUP.
Mr. PHILIP KIRKUP.
Mr. C. C. LEACH.
Prof. HENRY LOUIS.
Mr. J. H. MERIVALE.
Mr. JOHN MORISON.
Mr. W. C. MOUNTAIN.
Mr. HENRY PALMER.
Mr. M. W. PARRINGTON.
Mr. F. R. SIMPSON.
Mr. JOHN SIMPSON.
Mr. J. B. SIMPSON.
Mr. J. G. WEEKS.
Mr. W. O. WOOD.

The resolution was agreed to.

DR. THE TREASURER IN ACCOUNT WITH THE NORTH OF ENGLAND FOR THE YEAR ENDING

	£ s. d.	£ s. d.
June 30th, 1905.		
To Balance of Account at Bankers	500 17 11	
„ „ in Treasurer's hands	47 12 8	
„ Outstanding Accounts due from Authors for Excerpts	4 18 6	
		553 9 1
June 30th, 1906.		
To Dividend of 7½ per cent. on 179 Shares of £20 each in the Institute and Coal-trade Chambers Company, Limited, for the Year ending June 30th, 1906 ...	268 10 0	
„ Interest on Mortgage of £1,400 with the Institute and Coal-trade Chambers Company, Limited	49 0 0	
		317 10 0
To Sales of *Transactions*		44 4 3
To SUBSCRIPTIONS FOR YEAR 1905-1906 AS FOLLOWS:—		
752 Members ... ... @ £2 2s.	1,579 4 0	
86 Associate Members ... ... @ £2 2s.	180 12 0	
139 Associates ... ... @ £1 5s.	173 15 0	
44 Students ... ... @ £1 5s.	55 0 0	
45 New Members ... ... @ £2 2s.	94 10 0	
12 New Associate Members ... ... @ £2 2s.	25 4 0	
16 New Associates ... ... @ £1 5s.	20 0 0	
16 New Students ... ... @ £1 5s.	20 0 0	
	2,148 5 0	
25 Subscribing Firms £90 6 0		
5 New Subscribing Firms 10 10 0		
	100 16 0	
	2,249 1 0	
Less—Subscriptions for Current Year paid in advance at end of Last Year	60 9 0	
	2,188 12 0	
Add—Arrears received	287 16 0	
	2,476 8 0	
Add—Subscriptions paid in advance during the Current Year	49 19 0	
		2,526 7 0
		£3,441 10 4

INSTITUTE OF MINING AND MECHANICAL ENGINEERS Cr.
JUNE 30TH, 1906.

June 30th, 1906.	£	s.	d.	£	s.	d.
By *An Account of the Strata of Northumberland and Durham, as proved by Borings and Sinkings* ...	52	10	0			
„ *Annual Report*	35	17	9			
„ Banker's Charges	21	5	7			
„ Circulars and Advance Copies of Papers	49	19	2			
„ Cleaning Wood Memorial Hall, Offices, etc.	46	18	10			
„ Electric Light	25	19	5			
„ Expenses of Meetings	3	3	1			
„ Fire Insurance	13	5	9			
„ Fuel	18	2	7			
„ Furniture and Repairs	22	15	0			
„ Illustrations	2	10	0			
„ Incidental Expenses	5	9	8			
„ Lecture Theatre	60	8	7			
„ Library—Binding ... £64 16 0						
„ „ Books 23 11 11						
	88	7	11			
„ Petty Cash	4	4	3			
„ Postages—Circulars £31 15 6						
„ „ Correspondence 15 13 10						
„ „ Publications 29 11 3						
	77	0	7			
„ Prizes for Papers	15	15	0			
„ Rates and Taxes	6	3	6			
„ Rent of Offices	24	14	0			
„ *Report of the Committee upon Mechanical Coal-cutting*	114	13	5			
„ Reporting of General Meetings	12	12	0			
„ Salaries, Wages, Auditing, etc.	472	3	2			
„ Stationery, etc.	26	19	11			
„ *Subject-matter Index of Mining, Mechanical and Metallurgical Literature*	7	10	0			
„ Telephone Rent	3	3	6			
„ Translations of Papers	4	5	0			
„ Water Rate	3	7	8			
				1,219	5	4
By The Institution of Mining Engineers	1,327	16	6			
Less—Amounts paid by Authors for Excerpts ...	2	11	0			
				1,325	5	6
				2,544	10	10
By Balance of Account at Bankers	840	11	3			
„ „ in Treasurer's hands	53	9	9			
„ Outstanding Accounts due from Authors for Excerpts	2	18	6			
				896	19	6
				£3,441	10	4

DR. THE TREASURER OF THE NORTH OF ENGLAND INSTITUTE OF MINING

		£ s. d.	£ s. d.	£ s. d
To 953 Members.				
52 of whom have paid Life-compositions.				
901				
6 not included in printed list.				
907	@ £2 2s.	... ...	1,904 14 0	
To 113 Associate Members.				
8 of whom have paid Life-compositions.				
105	@ £2 2s.	... ...	220 10 0	
To 178 Associates,				
1 of whom has paid a Life-composition.				
177	@ £1 5s.	... ...	221 5 0	
To 56 Students.				
56	@ £1 5s.	... ...	70 0 0	
To 28 Subscribing Firms				
28		... ...	107 2 0	2,523 11 0
To 44 New Members	@ £2 2s.	92 8 0		
1 New Member, not yet elected	@ £2 2s.	2 2 0		
45			94 10 0	
To 12 New Associate Members	@ £2 2s.		25 4 0	
To 16 New Associates	@ £1 5s.	... ...	20 0 0	
To 16 New Students	@ £1 5s.	... ...	20 0 0	
To 5 New Subscribing Firms	@ £2 2s.	... ...	10 10 0	170 4 0
				2,693 15 0
To Arrears, as per Balance Sheet, 1904-1905 ...		... ...	372 7 0	
Add—Arrears considered irrecoverable, but since paid...			94 8 0	466 15 0
				3,160 10 0
To Subscriptions paid in advance				49 19 0
				£3,210 9 0

AND MECHANICAL ENGINEERS IN ACCOUNT WITH SUBSCRIPTIONS, 1905–1906. CR.

			PAID. £ s. d.	UNPAID. £ s. d.	STRUCK OFF LIST. £ s. d.
By 752	Members, paid	@ £2 2s.	1,579 4 0	.....	.....
By 110	„ unpaid ...	@ £2 2s.	.....	231 0 0	...
By 3	„ excused payment	@ £2 2s.	.....	.....	6 6 0
By 6	„ dead	@ £2 2s.	.....	.....	12 12 0
By 36	„ struck off list	@ £2 2s.	.....	.....	75 12 0
907					
By 86	Associate Members, paid	@ £2 2s.	180 12 0	.....	.....
By 16	„ „ unpaid	@ £2 2s.	.....	33 12 0	.....
By 1	„ „ excused	@ £2 2s.	.....	.....	2 2 0
By 1	„ „ dead	@ £2 2s.	.....	.....	2 2 0
By 1	„ „ struck off list		... ..	.....	2 2 0
105					
By 139	Associates, paid	@ £1 5s.	173 15 0	.....	.....
By 28	„ unpaid ...	@ £1 5s.	.....	35 0 0	.. ...
By 2	„ excused ...	@ £1 5s.	.....	.....	2 10 0
By 8	„ struck off list	@ £1 5s.	.....	.....	10 0 0
177					
By 44	Students, paid	@ £1 5s.	55 0 0	.....	.....
By 10	„ unpaid ...	@ £1 5s.	.....	12 10 0	.....
By 2	„ struck off list...	@ £1 5s.	.....	.....	2 10 0
56					
By 25	Subscribing Firms, paid		90 6 0	.....	.. ...
By 3	„ „ unpaid		.....	16 16 0	.....
28					
By 45	New Members, paid ...	@ £2 2s.	94 10 0	.....	.....
By 12	New Associate Members, paid	@ £2 2s.	25 4 0	... ..	.....
By 16	New Associates, paid ...	@ £1 5s.	20 0 0	.....	.....
By 16	New Students, paid ...	@ £1 5s.	20 0 0	.....	.....
By 5	New Subscribing Firms, paid	@ £2 2s.	10 10 0	.....	.. ...
			2,249 1 0	328 18 0	115 16 0
By Arrears			287 16 0	90 17 0	88 2 0
			2,536 17 0		
By Subscriptions paid in advance			49 19 0	.....	.....
			2,586 16 0	419 15 0	203 18 0
					419 15 0
					2,586 16 0
					£3,210 9 0

Liabilities.

	£ s. d.	£ s. d.
Subscriptions paid in advance during the current year		49 19 0
The Institution of Mining Engineers		2 19 6
The George Clementson Greenwell Prize Fund	100 0 0	
Less—Paid for Medals	67 8 4	
		32 11 8
Capital		12,219 7 6
		£12,304 17 8

We, having examined the above account with the books, vouchers and securities relating thereto, certify that, in our opinion, it is correct. We have accepted the assets, books, pictures, maps, etc., and *Transactions* and other publications as valued by your Officials.

JOHN G. BENSON AND SONS,
Chartered Accountants.

Newcastle-upon-Tyne,
August 2nd, 1906.

Assets.

	£ s. d.	£ s. d.
Balance of Account at Bankers	840 11 3	
„ in Treasurer's hands	53 9 9	
Outstanding Accounts due from Authors for Excerpts	2 18 6	
		896 19 6
Arrears of Subscriptions		419 15 0
179 Shares in the Institute and Coal-trade Chambers Company, Limited (at cost) ...	4,100 0 0	
Investment with the Institute and Coal-trade Chambers Company, Limited (mortgage) ...	1,400 0 0	
		5,500 0 0
(Of the above amount, £1,586 is due to Life-subscriptions Account.)		
Value of *Transactions* and other Publications, as per Stock Account	338 3 2	
Books, Pictures, Maps, Furniture and Fittings	5,150 0 0	
		5,488 3 2
		£12,304 17 8

G. C. GREENWELL MEDALS.

The CHAIRMAN (Mr. T. W. Benson) said that the medals were founded by their late friend Mr. G. C. Greenwell, who, as the older generation of the members knew, was an original member of the Institute, one of the early members of the Council, and a past-president. He had pleasure in presenting G. C. Greenwell medals to Messrs. W. C. Blackett and R. G. Ware for their most useful and practical paper on "The Conveyor-system for Filling at the Coal-face, as practised in Great Britain and America."* It was deeply to be regretted that one of the recipients—Mr. R. G. Ware—had died since the paper was written; and he was sure that it was the desire of the members that the Secretary, in forwarding the medal to the mother of the deceased gentleman, should convey their regrets and deepest sympathy.

Mr. W. C. BLACKETT said that he was very grateful to the Council for the honour done to him, although his pleasure in receiving the Greenwell medal was sadly marred by the fact that Mr. Ware, who had been awarded a companion medal, had passed away. He was glad that the relatives that he had left would receive some little comfort from the fact that this distinction was paid to him after his death.

The CHAIRMAN (Mr. T. W. Benson) handed to Mr. M. Walton Brown the G. C. Greenwell medal awarded to Mr. D. M. D. Stuart for his paper on "The Development of Explosives for Coal-mines."†

Mr. M. WALTON BROWN, in acknowledging the receipt of the medal, said that Mr. Stuart was very gratified to receive the Greenwell medal awarded to him for his paper upon "The Development of Explosives for Coal-mines." He assured the Council that he very deeply appreciated the honour that they had conferred upon him, and he would treasure that high distinctive recognition of his endeavour to contribute, in however small a way, to the great work of the Institute in promoting the safety of mining.

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* *Trans. Inst. M. E.*, 1905, vol. xxix., page 449.

† *Ibid.*, page 299.

The following gentlemen were elected, having been previously nominated:—

MEMBERS—

Mr. EDWARD WILLIAM ANDREWS, Electrical Engineer, 4, Ashwood Terrace, Sunderland.

Mr. OWAIN TUDOR EDWARDS, Mining Engineer, care of The G. I. P. Railway Company, Mopani Collieries, Central Provinces, India.

Mr. ERNEST LONG, Electrical Engineer, care of Messrs. W. T. Glover and Company, Limited, Trafford Park, Manchester.

Mr. AUGUSTIN JOSEPH MCINERNY, Mining Engineer, 16, Rue d'Autriche, Tunis.

Mr. WILLIAM ROBERTS, Mining Engineer, Bella Vista, Perranporth, S.O., Cornwall.

ASSOCIATE MEMBER—

Mr. ANDREW SELBY WOOD, Caledonian Buildings, Pilgrim Street, Newcastle-upon-Tyne.

STUDENT—

Mr. JOHN ANTHONY SYDNEY RITSON, Mining Student, Burnhope Colliery, Lanchester, Durham.

Mr. WILLIAM GALLOWAY'S paper on "An Appliance for Automatically Stopping and Restarting Mine-wagons" was read as follows:—

AN APPLIANCE FOR AUTOMATICALLY STOPPING AND RESTARTING MINE-WAGONS.*

By Prof. W. GALLOWAY.

The points at which this appliance can be most usefully employed are at the weighing-machine between the top of the shaft and the screens, and in front of the cage at the top and bottom of the shaft. Its functions are to arrest the motion of a full or empty wagon without shock, to hold it stationary as long as may be necessary, and then to push it forward, with any desired velocity, in the direction in which it was originally moving. These operations are accomplished without the intervention of an attendant, except that, at the instant of restarting, a lever is moved either by hand or foot which requires only the smallest imaginable exertion of force on the part of the weigher, banksman, or hitcher, as the case may be. By this appliance, all the weighing on the surface and the loading and unloading of the cages at the top and bottom of the shaft have been effected automatically, and without a hitch, for upwards of a year, at Garth colliery, near Maesteg, South Wales, belonging to Messrs. Elder's Navigation Collieries, Limited.

Figs. 1, 2 and 3 (Plate I.) represent a sectional elevation, a plan and an end elevation respectively, of its application to a weighing-machine. A rectangular sheet-iron frame, *A*, sliding on eight supports, *b*, two on each side of the cylinder, *C*, and two fixed to each end of the frame which surrounds the weighing-platform, carries a set of Fisher catches, *c* and *c'*, which always occupy the positions shown in Fig. 1, when left to themselves. The frame, *A*, is attached to a piston-rod, *B*, which passes through a stuffing-box (in which metallic packing is used by preference), and is fixed to a piston, *d*, in the interior of the cylinder, *C*. A pipe, *e*, with a valve, *o*, which is always open unless some unexpected emergency arises, connects the inside of the cylinder

* British patent, 1904, No. 25,344.

on the left-hand side of the piston with the air-compressing engine, which is common to all the other compressed-air machines used at the colliery. Another pipe, *g*, with a valve, *p*, which is regulated to suit requirements, connects the ends of the cylinder with each other. A third pipe, *f*, with a valve, *q*, which is opened when the foot-plate, *m*, is pressed down, and is closed automatically by the weight, *t*, passes from the right-hand end of the cylinder under the floor of the weighing-machine house to a point where the foot-plate is convenient to the weigher, and thence out again from under the floor at the other side of the house. The compressed air has thus a free passage into the cylinder on both sides of the piston, and thence into the pipe, *f*, as far as the valve, *q*.

When the valve, *q*, is shut, the air within the cylinder is at the same pressure on both sides of the piston: but the area of the left-hand side of the piston being less than that of its right-hand side by the amount of the area of the piston-rod, the piston, the piston-rod, the frame attached to it, and any wagon that happens for the moment to be held between the catches, are drawn towards the left-hand side as far as the piston can move. The force with which a movement towards either the left- or right-hand side is effected depends on the relative areas of the piston and piston-rod on the one hand and the pressure of the air on the other, all of which must be taken into account when the required forces are calculated. In approaching the left-hand end of the cylinder, the piston covers the opening into the pipe, *g*, and in approaching the other end of the cylinder it covers the opening into the pipe, *f*. It is thus cushioned at each end, and prevented from striking the corresponding ends of the cylinder.

The operation of weighing is effected as follows: The axles of the full wagon, running at any velocity less than that required to overturn it, successively depress and pass over the catches, *c*, which immediately rise up behind them. No sooner is the hinder axle clear of the catches, *c*, than the front axle, coming in contact with and pressing against the catches, *c'*, with the full force due to the momentum of the wagon, pushes the frame, A, and its connections, including the piston within the cylinder, to a greater or less distance in the same direction from a few inches

to a foot, according to the greater or less velocity at which the wagon has been moving. But the pressure of the air within the cylinder, now acting like a spring, arrests the forward motion of the wagon and then draws it back until it stands directly over the centre of the weighing-platform. The operation of weighing having been completed, the weigher places his foot on the foot-plate and thereby opens the valve, q. The air-pressure, being thus withdrawn from the right-hand side of the piston, the latter, together with the frame, is pushed towards the right-hand side and the catches, c, pressing against the hinder axle of any wagon that happens to be in front of them, drive it forward at a greater or less velocity, according to the greater or less diameter of the cylinder and the higher or lower pressure of the air acting on the piston. When the frame has nearly reached the end of its intended stroke, a knob, n, on the end of a rod, h, attached to a crank, l, on the shaft, d'', to which the catches, c', are keyed, comes into contact with a spring, s, in front of a standard, k (fixed to the weighing-platform), through a hole in which the rod, h, can pass freely. The spring arrests the forward movement of the rod: the catches, c', are thereby depressed: and the wagon, continuing to run forward after the frame has come to a standstill, passes over them, and proceeds towards its destination. As soon as the hinder axle of the wagon is clear of the catches, c', the weigher removes his foot from the foot-plate, the valve, q, closes automatically, the pressure of the air on the right-hand side of the piston is restored through the pipe, g, and the valve, p, and the frame, A, is drawn back to its original position, ready to receive another wagon. The rapidity with which the frame is drawn back depends on the area of the opening of the valve, p. The frame, A, is covered with a sheet of iron to prevent coal or rubbish from falling into its interior, and the only openings in it are those through which the catches, c and c', project.

The valve, p, can be closed and opened by the same lever as that which opens and closes the valve, q; in fact this is applied in the apparatus employed at the weighing-machine at Garth colliery. In the same apparatus, a chain with a spring is used, instead of the rod, h (Figs. 1 and 2, Plate I.). A slide-valve can be used, in place of the valves, p and q; vertical catches held up by springs or counter-weights acting on levers

can be used, instead of the Fisher catches; steam or water, under pressure, can be used, instead of compressed air; and the details can thus be varied in many ways.

The points to be specially noted are: that the moving wagons are arrested gently, held in the desired position, and again discharged with the required velocity without muscular effort on the part of an attendant, and that, thereby, a substantial saving in both time and labour, is effected.

The average rate at which tubs, each carrying 1 ton, can be stopped, steadied, weighed and disposed of by this apparatus in the manner described, as applied at Garth colliery, is six per minute, or, more accurately, one tub per 9·58 seconds. The time occupied in pushing a full or empty tub of the same capacity into the cage and thereby discharging the empty or full tub, in front of it, is about 3 seconds.

Mr. J. G. Weeks said that the apparatus described by Mr. Galloway probably removed the difficulty arising from men pressing on the tubs while they were on the weighing-machine. Contrivances were in use in this district, which carried out the same object, without using compressed air, electricity or steam, as they were simply actuated by the weight of the tub being pushed against the apparatus. It was a great advantage in weighing a tub not to have to weigh the banksman as well, as this was a tare which was difficult to take off. He thought that the paper was valuable in directing attention to this matter, which was often a serious and troublesome one.

Mr. George May said that several systems had been adopted in this district for holding the tub on the weighing-machine, and for releasing it by the axle of the next approaching tub, which on taking its place became (for the time being) secured.

Mr. Thomas Douglas moved a vote of thanks to Mr. Galloway for his paper. Other members were no doubt attempting to deal with the problem, which in this district would require different treatment, seeing that the tubs used here only averaged about 8 hundredweights.

To illustrate Prof. W. Galloway's Paper on "An Appliance for Automatically Stopping and Restarting Mine-wagons."

FIG. 1.—SECTIONAL ELEVATION.

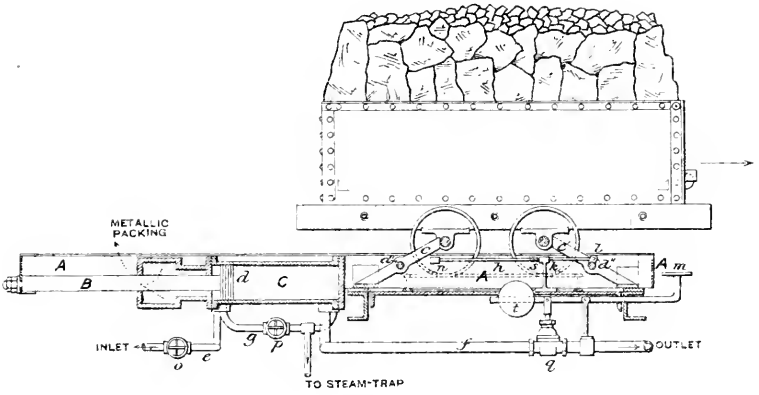


FIG. 2.—PLAN.

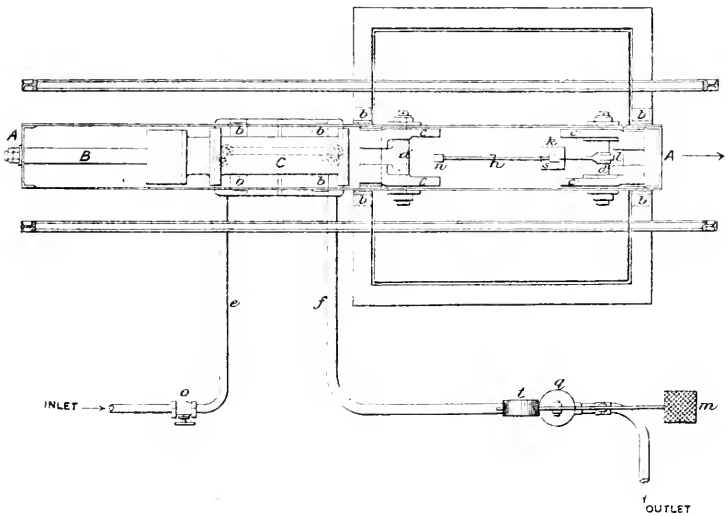
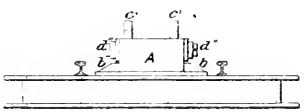


FIG. 3.—END ELEVATION.



Scale, 3 Feet to 1 Inch.

And.ᵂ Reid & Compʸ Lᵗᵈ Newcastle upon Tyne

Mr. J. H. Merivale, in seconding the vote of thanks, said that, if the apparatus was combined with some arrangement for running the tubs out of the cage, it would be exceedingly useful. Still, except for the purpose suggested by Mr. Weeks, he did not see how they would derive much advantage from automatic weighing, as they must always have a banksman in attendance.

Mr. W. C. Blackett pointed out that, in the case described in the paper, the loading and unloading of the cages at the top and bottom of the shaft was done automatically, so that a banksman would not necessarily be in attendance.

Mr. C. B. Palmer said that, at Felling colliery, the tub was never touched by a workman after leaving the cage until it came to the tippler. It was crept automatically over the weighing-machine, it was weighed while moving, upon a long weigh-bridge, and it was therefore unnecessary for anyone to touch the tub while on the weighing-machine.

Mr. W. Galloway stated that the apparatus could be made to deal with any weight of tub, large or small, and that it was in constant use for running tubs into and out of the cages, both at the top and bottom of the Garth colliery, near Maesteg. The latter point appeared to have escaped the notice of Mr. Merivale.

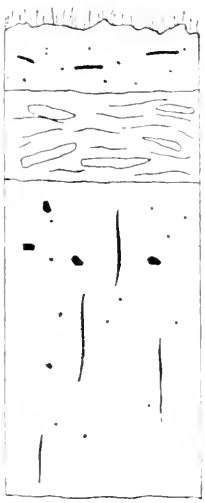
The vote of thanks was cordially adopted.

Dr. J. A. Smythe's paper on "Deposits in a Pit-fall at Tanfield Lea, Tantobie, County Durham" was read as follows:—

DEPOSITS IN A PIT-FALL AT TANFIELD LEA, TANTOBIE, COUNTY DURHAM.

By J. A. SMYTHE, M.Sc., Ph.D.

Introduction.—This pit-fall, as seen on May 15th, 1905, was a round hole about 24 feet across and 12 to 15 feet deep. The section on the west side showed an old peat-bed, underlain by sandy clay; the peat thinned out quickly to the east, and the



Description of Strata.	Thickness of Strata. Feet.	Depth from Surface. Feet.
Soil, containing a few slabs of flaggy sandstone, made ground (?)	1	1
Peat, with stumps, roots and branches ...	2	3
Sandy clay, with "black stuff" in pockets and rifts	6	9

FIG. 1.—SECTION AT WESTERN END OF PIT-FALL. SCALE, 4 FEET TO 1 INCH.

sandy clay gave place to sand, so that the fall had evidently occurred at the edge of an old peat-bog, although there were no surface-indications of such. The peat, containing stumps of wood and roots, some in an advanced state of decomposition, others still fresh and fibrous, was overlain by about 1 foot of soil (probably made ground), and rested upon sandy clay containing a peculiar black jelly-like substance, irregularly distributed in pockets and clefts (Fig. 1). The actual quantity of this "black stuff" was small, although it was fairly widely dispersed, sometimes as a thin lining to fissures in the clay. It was nowhere seen to be in actual connection with the peat, but

from its occurrence only beneath it (and from chemical evidence to be given shortly), there can hardly be any doubt that it was derived from it. Some of the larger pockets, about 1 foot below the peat-bed, yielded 2 or 3 cubic inches of the deposit.

Analyses.—The deposit was seen to have a conchoidal fracture and a concentric arrangement of layers, and it could be peeled somewhat like a boiled onion; on drying in air it lost 76 per cent. of water and formed a hard black substance with conchoidal fracture, grinding to a dark brown powder. The peat and the partly decomposed wood embedded in it, formed brown powders on drying and grinding. These three bodies will be referred to hereafter as black stuff, peat and wood.

Under the microscope, the black stuff appears as a greenish-yellow transparent body, stratified, but quite devoid of any plant structure. The air-dried samples gave on analysis:—

	Moisture.	Ash.	Volatile Matter.	Fixed Carbon.
Black stuff	16·43	7·23	55·55	20·79
Peat	16·05	9·75	49·44	24·76
Wood	14·12	4·12	56·00	25·76

All three yield friable cokes or cokey powders, and the ash is white in the case of the peat, buff in that of the other two. For better comparison these results are here recalculated on the basis of dry ash-free material:—

	Volatile Matter.	Fixed Carbon.
Black stuff	72·80	27·20
Peat	66·66	33·34
Wood	68·48	31·52

These figures bring out clearly the similarity of the peat and wood. The somewhat higher percentage of volatile matter in the black stuff is what might be expected, on the assumption that it is derived from the peat by some process of solution and deposition. The ultimate analysis of the dry materials gave:—

	Carbon.	Hydrogen.	Nitrogen.	Sulphur.	Ash.	Oxygen (by difference).
Black stuff ...	49·22 | 49·36	5·14 | 5·16	2·33 | 2·49	1·41	11·23	30·51
Peat	—	—	1·55	—	—	—
Wood	—	—	0·92	—	—	—

The low percentage of total carbon and the high percentage of volatile matter suggest that the black stuff is similar rather

to the carbohydrates than to coal. This is brought out clearly in the following table, in which the black stuff is compared with three of the typical carbohydrates, namely, cellulose, starch, and cane-sugar.

	Total Carbon	Total Hydrogen.	Volatile Matter.	Fixed Carbon.
Cellulose	44·44	6·17	87·60	12·40
Starch	44·44	6·17	83·52	16·48
Cane-sugar	42·11	6·44	79·85	20·15
Black stuff (ash-free) ...	55·54	5·80	72·80	27·20

Reference may perhaps be made here to the rise in the percentage of nitrogen which accompanies the metamorphosis of the vegetable matter. According to Prof. A. Delesse,* the woody parts of plants contain less nitrogen than the leaves, and mosses are fairly rich in that element. It is thus not unnatural that the peat, which is only partly made up from wood, should contain more nitrogen than the wood embedded in it, and that the black stuff, which has lost all woody structure, should contain most nitrogen of all.

Extraction with Solvents.—Dry chloroform dissolves about 1 per cent. by weight of the black stuff, peat and wood after 3 hours' extraction. The yellow solution leaves a waxy solid on evaporation of the chloroform, and this solid, on purification by dissolving in benzene and precipitating with petroleum-ether, is obtained in the form of a greenish powder, melting about 90° Cent. and burning with a long, smoky flame when heated on platinum. The result in all three cases is the same.

The residues from the chloroform treatment, when extracted for 6 hours with pyridine, yield dark brown solutions from which acids precipitate a humus-like substance, acidic in character. The amount extracted is about 5 per cent. in the case of the black stuff, and slightly less in that of the wood and peat.

Dr. P. P. Bedson† first described, in 1899, the solvent action of pyridine on coal. In extending this work, Mr. T. Baker‡ discovered that pyridine dissolves out from coal some, at least,

* "Recherches de l'Azote et des Matières Organiques dans l'Écorce Terrestre," by Prof. A. Delesse, *Annales des Mines*, 1860, vol. xviii., page 219.

† "Results of the Analysis of Samples of New Zealand Coal and Ambrite, and of Barbados Manjak," by Dr. P. Phillips Bedson, *Trans. Inst. M. E.*, 1899, vol. xvi., page 388.

‡ "The Solvent Action of Pyridine on Certain Coals," by Mr. T. Baker, *Trans. Inst. M. E.*, 1900, vol. xx., page 159.

of the constituents richer in hydrogen, and, furthermore, that the presence of these constituents influences in a remarkable way the coking power of the coal. Thus a coal with moderate coking properties is rendered non-coking by treatment with pyridine, but the pyridine extract has greatly enhanced coking properties compared with the original coal.

Exactly similar phenomena are met with in studying the solvent action of pyridine upon the black stuff from Tantobie. Not only do the pyridine solutions resemble those from coal, but the extracts are richer in volatile matter (and presumably in hydrogen also), and they coke much more readily than the original stuff itself, and still more so than the extracted residue. Thus, proximate analysis of the residue and extract from the pyridine treatment of the black stuff gave the following results:—

	Volatile Matter.	Fixed Carbon.	Ash.
Extract ...	79·24	20·29	0·47
Residue ...	48·04	37·41	14·55

The original and the residue both gave a cokey powder; the extract yielded a compact glistening coke. Comparing these results with the original black stuff, and recalculating all on ash-free material, the results are as follow:—

	Volatile Matter.	Fixed Carbon.
Black stuff	72·80	27·20
Extract	79·64	20·36
Residue	56·30	43·70

Mr. Baker's results* from the pyridine extraction of coal from the Hutton seam may be compared with the foregoing. Mr. Baker's figures are here recalculated on the dry ash-free material:—

	Volatile Matter.	Fixed Carbon.
Coal	30·96	69·04
Extract	54·45	45·55
Residue	32·84	67·16

It will be noticed that, both in the case of the coal and of the Tantobie black stuff, the volatile matter is greater in the pyridine extract, and smaller in the insoluble residue, than in the original materials; and corresponding to this, the extracts yield better cokes than the original bodies or the insoluble residues.

* *Trans. Inst. M. E.*, 1900, vol. xx., page 160.

It is thus evident that, in respect to the action of pyridine, and to the coking properties of the original material and the products of extraction, the black stuff bears the closest analogy to bituminous coal. That it should also resemble, in some ways, the carbohydrates, as pointed out above, is perhaps not unnatural when the connection between cellulose and coal is considered.

Some recent deposits having, apparently, some of the characters of the Tantobie black stuff have been described by Prof. H. Potonié.* They are formed on the Ahlbecker See from muddy matters containing animal and vegetable remains, and are fermented in the absence of oxygen. The consistency of these muds is that of a jelly; they show a delicate stratification and a conchoidal fracture very like the bituminous shales with *Cypridina* of the Coal-measures. They are so rich in nitrogen as to be worked for the extraction of ammonia.

The author wishes, in conclusion, to express his best thanks to Messrs. W. A. Swallow and T. Adamson, of Tanfield Lea colliery, for having brought this matter to his notice and for having given him every facility to examine the pit-fall; to Mr. E. Jeffrey, B.Sc., of the Armstrong College, for carrying out the four nitrogen determinations embodied in the text; and to Prof. G. A. Lebour for the references to the foreign literature quoted in the paper.

The Chairman (Mr. T. W. Benson) moved a vote of thanks to Dr. Smythe for his interesting paper.

Mr. J. H. Merivale seconded the resolution, which was cordially approved.

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* "Eine rezente organogene Schlamm-Bildung des Cannelkohlen-Typus," by Mr. H. Potonié, *Jahrbuch der Königlich Preussischen Geologischen Landesanstalt und Bergakademie zu Berlin*, 1903, vol. xxiv., pages 405-409; *Trans. Inst. M. E.*, 1904, vol. xxviii., page 742; and *Annales de la Société Géologique de Belgique*, 1904, vol. xxxii., bulletin, page 49.

ELECTRO-BAROGRAPH FOR MINES.*

The Thwaite electro-barograph has been invented to secure the automatic and audible signalling of a sudden and dangerous drop of mine-pressure.† It consists of an aneroid barometer, A, fitted with three dry cells, B, and a signal-bell, C (Fig. 1). The contact-maker, *a*, may be adjusted at the beginning of each shift, or any other appointed time, so that the pointer, *b*, is placed at the

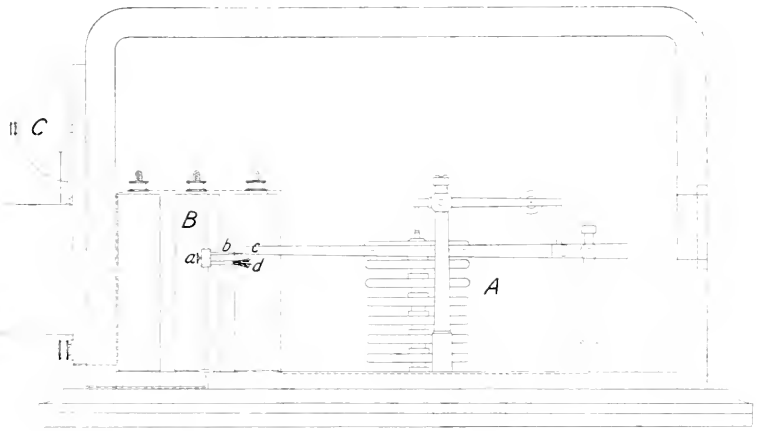

Fig. 1.—Elevation of Thwaite Electro-barograph.

level of the underside of the bar, *c*. The distance between the pointer, *b*, and the brush or contact-maker, *d*, is adjusted to the requirements of each mine. As soon as the bar, *c*, of the barometer falls a certain distance, measured by the interval between the pointer, *b*, and the brush, *d*, electric contact takes place between the bar, *c*, and the brush, *d*, and the bell rings, wherever the instrument is placed in the mine.

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* British patent, October 7th, 1905, No. 20,291.

† "Can Explosions in Coal-mines, with their associated Toxic Fatalities, be prevented," by Mr. B. H. Thwaite, *Trans. Inst. M. E.*, 1905, vol. xxx., page 389.

THE NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

EXCURSION MEETING OF ASSOCIATES AND STUDENTS,
HELD AT BOWBURN WINNING, SEPTEMBER 10TH, 1906.

BOWBURN WINNING.

BY A. L. STEAVENSON.

At Bowburn winning, a shaft was seen in the process of being sunk by piling through the thick Glacial Drift of clay and sand, which covers the surface in the neighbourhood of Durham city.

As this difficult material was known to exist, a bore-hole had been put down a few feet from the position of the proposed pit, finding no rock until a depth of 156 feet 9 inches had been reached (Appendix). It was then determined that the shaft would necessitate piling, and the pit was started 25 feet in diameter, in order to make sure of finishing with a shaft 13 feet in diameter. The pit was sunk by ordinary methods to a depth of 89 feet 3 inches, through stony clay; and, on penetrating for a depth of 18 feet into the loamy clay (No. 6 bed, Appendix), it was determined that piling must begin at once.

The cribs, *a*, were 6 inches square, with backing-deals, *b*, $1\frac{1}{4}$ inches thick and 7 inches wide, and tied with stringing-deals, *c*, $1\frac{1}{4}$ inches thick and 7 inches wide. The cribs were spaced 21 inches apart, with punch-props, *d*, 4 inches in diameter. The lowest crib of this timbering was inserted at a depth of 101 feet, and the lower portion was lined with grooved and tongued deals, *e*, $1\frac{1}{4}$ inches thick and 7 inches wide (Figs. 1 and 2, Plate XVI.).

A crib, *f*, 6 inches square, was then suspended by chains, leaving a space of $2\frac{1}{2}$ inches for the passage of the piles; and below this a similar crib, *g*, was laid but not hung, the segments being fastened together above and below, by iron plates, 3 feet long, 3 inches wide and $\frac{1}{2}$ inch thick, bolted with six through-

bolts, and going down with the piling. The pitchpine piles, *h*, 7 inches wide and 2½ inches thick, were scarfed for a length of 6 inches, and blacklead was applied to make them travel easily. The piles were driven downward by blows from a ram of pitchpine, worked by three men: one standing near the lower end, and two at the top end. Longer rams were used as the piles descended into position. As the piles went downward, the sand below was removed, so as to keep the sinking-curb going down; and, when lowered far enough, other cribs, *a*, 6 inches square, were placed, spaced 15 inches from centre to centre. The first section was 15 feet long.

When these piles were driven down, the cribs were lined with deals, *c*, 1¼ inches thick and 7 inches wide, as before. A second crib was hung, leaving a space for another ring of piles: the outside diameter being 21 feet 6½ inches. A second length of piling was then driven down a distance of 15 feet, and a third length of piles in the same way, the outside diameter of the piling being 20 feet 4 inches. These piles were 18 feet long and shod with sheet-iron, ⅛ inch thick. The heads of all the piles were hooped with iron, 2½ inches wide and ½ inch thick.

The last crib having entered the sandstone, the usual method of sinking was resumed. After another length of 6 feet had been accomplished, a good crib-bed was made, and all this bad ground was walled off with two rings of firebrick-lumps, *i* and *k*, 12 inches long, 9 inches wide and 3 inches thick, and cement-grouting, *j*, 3 inches thick, between them. The space behind the walling was rammed with well-puddled clay. The timber was left behind the walling.

The greatest quantity of water encountered was about 30 gallons per minute, which was, of course, quite sufficient to make the sand run freely had it not been carefully treated. The whole operation was finished in about nine weeks.

During the sinking through the Glacial Drift, many boulders of blue limestone from West Durham were found, deeply scratched in their rough journey, similar to those described by Prof. James Geikie.*

Since the walling was completed, a depth of 192 feet has been attained: and, at present, in a mild freestone, feeders amounting to 800 gallons of water per minute are being successfully dealt

* *The Great Ice Age*, by Prof. James Geikie, 1874, page 9.

with by two pumps slung in chains from the surface. It is expected that the Low Main seam will soon be reached, and at the first good rock, the water will be tubbed off.

The shaft was started 25 feet in diameter, so as to make sure of getting a finished size of 13 feet in diameter; but having been successful in getting down with less loss of dimensions than was expected, a size of 15 feet in diameter has been adopted.

Few similar sinkings necessitating piling have been required in this district; but the late Mr. G. C. Greenwell described the piling of a pit at Framwellgate Moor 60 years ago.* In that case, the pit was started with a diameter of 30 feet, and ended with a diameter of only $14\frac{1}{3}$ feet. Timber of sufficient strength not having been used, at one point the pit was filled with ashes; and the sinking was recommenced with stronger timber, eventually getting into blue metal-stone at a depth of 120 feet.

The late Mr. Edward Potter described the piling of a pit through the sand at the bottom of the Magnesian Limestone.† In this case, the pits having been tubbed to a depth of 456 feet, were belled-out from 14 feet, the finished size, to a diameter of $21\frac{1}{2}$ feet. As much as 9,306 gallons of water per minute was pumped at one time.

About $\frac{1}{4}$ mile to the east of this Bowburn pit is an old shaft sunk by the late Mr. Quelch. He was most unfortunate, for, having passed through the Low Main and Hutton seams, both too thin to work in those times of 50 years ago, he bored to a point at which he should have found the Busty bank seam. However, there happened to be a nip-out, and he abandoned the sinking with, no doubt, considerable loss. Had his pit been sunk a few feet further west, he would have got nearly 5 feet of coal, as proved by the present owners. The moral to be drawn is: "In cases of importance do not trust a single bore-hole." This old pit is lined with timber tubbing, and it is still quite good.

The late Mr. G. C. Greenwell described the mode of inserting timber tubbing,‡ and stated that it was not uncommon to see a

* *A Practical Treatise on Mine Engineering*, by Mr. G. C. Greenwell, 1855, page 127; and second edition, 1869, page 160.

† "Murton Winning in the County of Durham," by Mr. Edward Potter, *Trans. N. E. Inst.*, 1856, vol. v., page 43.

‡ *A Treatise on the Winning and Working of Collieries*, by Mr. Matthias Dunn, 1848, page 92; and second edition, 1852, page 49. *A Practical Treatise on Mine Engineering*, by Mr. G. C. Greenwell, 1855, page 135; and second edition, 1869, page 170.

tub of this description sustain a pressure of 300 feet of water. The previous system of plank-tubbing, used when sinking Hebburn colliery in 1790, is also described by Mr. G. C. Greenwell.*

APPENDIX.—SECTION OF STRATA PASSED IN A BORE-HOLE AT BOWBURN WINNING, JANUARY, 1906.

No.	Description of Strata.	Thickness of Strata. Ft.	Ins.	Depth from Surface. Ft.	Ins.
1	Soil	1	0	1	0
2	Yellow clay	1	2	2	2
3	Stony clay ...	14	2	16	4
4	Sand-parting, with water	0	7	16	11
5	Stony clay	72	4	89	3
6	Loamy clay	19	7	108	10
7	Quicksand	4	6	113	4
8	Leafy clay	16	8	130	0
9	Stony clay	2	2	132	2
10	Loam...	3	4	135	6
11	Clay, loam, sand and gravel, with water	6	9	142	3
12	Stony clay	14	6	156	9
13	Freestone	5	3	162	0

NOTE.—The borers stated that, so far as they could judge, there would not be any great feeders of water to be dealt with, but it will be observed that, from the depth of 90 feet, difficult ground was encountered.

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* *A Treatise on the Winning and Working of Collieries*, by Mr. Matthias Dunn, 1848, page 89; and second edition, 1852, page 47. *A Practical Treatise on Mine Engineering*, by Mr. G. C. Greenwell, 1855, page 135; and second edition, 1869, page 169.

The Institution of Mining Engineers.
Transactions. 1906-1907.

To illustrate Mr. A. L. Steavenson's Notes on "Bowburn Winning."

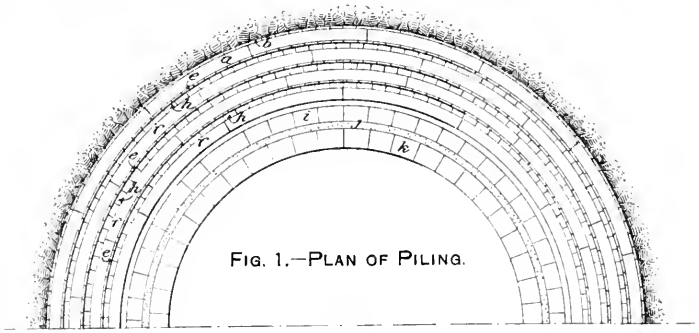
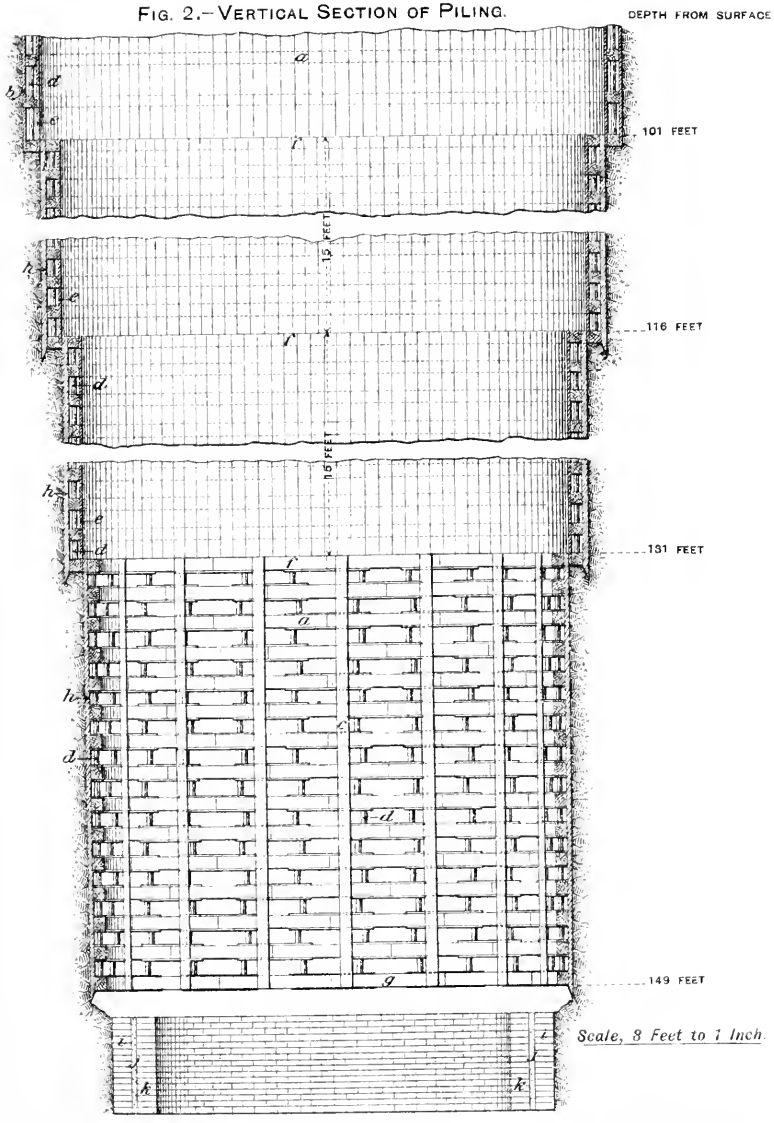


FIG. 1.—PLAN OF PILING.

FIG. 2.—VERTICAL SECTION OF PILING.



Scale, 8 Feet to 1 Inch.

The North of England Institute of Mining & Mechanical Engineers
Transactions. 1906-1907.

And.r Reid & Comp.y Ltd. Newcastle upon Tyne

THE NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

GENERAL MEETING,
HELD IN THE WOOD MEMORIAL HALL, NEWCASTLE-UPON-TYNE,
OCTOBER 13TH, 1906.

MR. J. H. MERIVALE, PRESIDENT, IN THE CHAIR.

DEATH OF MR. JOHN DAGLISH.

MR. THOMAS DOUGLAS said that, as one of the few surviving original members of the Institute and for many years a personal friend of the late Mr. John Daglish, he felt that he might say a few words with reference to his recent death. The Institute, like everything else, had a beginning; and, recalling the earliest day in the life of the Institute, he well remembered meeting the late Mr. John Daglish and the late Mr. Nicholas Wood, along with a few other gentlemen, on July 3rd, 1852, the outcome of which meeting was the establishment of the North of England Institute of Mining Engineers. It was to the mining engineers of that period, and others since eminent in the profession, that the members were largely indebted for the position which the Institute enjoyed and had always maintained, for the purpose of disseminating every possible influence to guide others in reference to matters connected with mine-engineering; and if there was one man more than another who had advanced the interests of the Institute it was their late friend. Of course, in that connection, he excepted the late Mr. Nicholas Wood, who took such an enormous interest in the Institute, and to whom they had been so greatly indebted for its maintenance in the large amount of time that he had devoted and the great number of papers that he had gathered together for the information of the members. He (Mr. Douglas) proposed that the members should express to Mr. Daglish's widow their deepest sympathy in her bereavement, and their high appreciation of her late husband's merits and of the help which he had given to the Institute during the many years that he had been connected with it.

Mr. A. L. Steavenson, in seconding the proposal, remarked that, although he himself did not become a member of the Institute until 1855, he was well aware of the great interest that Mr. Daglish had always taken in the affairs of the Institute. He had written many papers, and conducted many experiments and tests, notably with regard to mine-ventilation. As involving the loss of a personal friend, Mr. Daglish's death was a very great shock to himself, and he was sure that it was a very great loss to the Institute.

The President (Mr. J. H. Merivale) said that Mr. Daglish was one of the original members, and by his death only three now survived, namely, Mr. Charles William Anderson, Mr. Cuthbert Berkley and Mr. Thomas Douglas, all of whom the members hoped might be spared for many years yet to come. Mr. Daglish had taken an interest in that Institute from its inception in 1852, up to the day of his death, and although he was not in a position as yet to state anything officially, yet there was reason to believe that Mr. Daglish's name would continue to be connected with the Institute in a tangible way for all time to come.

The resolution was sympathetically adopted.

The Secretary read the minutes of the last General Meeting, and reported the proceedings of the Council at their meetings on August 18th, September 29th and that day, together with the proceedings of the Council of The Institution of Mining Engineers.

The following gentlemen were elected, having been previously nominated:—

Honorary Member—

Mr. Hugh Johnstone, H.M. Inspector of Mines, Stafford.

Members—

Mr. Charles Bernard Brodigan, Mining Engineer, P.O. Box 3, Brakpan, Transvaal.

Mr. Samuel Dean, Mining Engineer, Easington, Castle Eden, S.O., County Durham.

Mr. William Knox, Mechanical Engineer, Horden Colliery, Castle Eden, S.O., County Durham.

Mr. James Duncan Macarthur, Marine Engineer, Avondale, Finnart Road, Greenock.

Mr. Francis James Robinson, Electrical Engineer, Wycliffe, South Parade, Whitley Bay, S.O., Northumberland.

Mr. Frederick Augustus Yerbury, Mechanical Engineer, 14, Grange Road, Kingston-on-Thames.

ASSOCIATES—

Mr. FRANCIS MCDONALD, Miner, 164, Leadgate, S.O., County Durham.

Mr. ISAAC SCOBIE, Under-manager, Woonona, near Sydney, New South Wales, Australia.

STUDENT—

Mr. WILLIAM GRAHAM, JUN., Apprentice Mining Engineer, Solway House, Moresby, Whitehaven.

DISCUSSION OF MR. W. ARCHER'S PAPER ON "IMPROVED DAMPERS FOR COKE-OVEN FLUES."*

Mr. A. M. HEDLEY asked whether Mr. Archer could give any idea of the comparative costs of the dampers described in the paper, and the cost of renewals and repairs over a certain period, as compared with a damper of more simple construction. The first type of damper consisted of a cast-iron frame with inner cross-stays of solid bar-iron, covered and protected by overlapping fire-clay lumps; and in the second type, a framework of tubes was enclosed by a series of fire-clay lumps, air being admitted into the tubes for the purpose, as he took it, of keeping them cool and preserving them from being injured by the intense heat. The first type of damper seemed to be much simpler, and would probably cost less.

Mr. W. ARCHER said that the first cost of either damper was as cheap as that of any steel-plate damper. The plate-and-quarl damper was, if anything, more costly than the tube-and-quarl damper. A plate-and-quarl damper had been in use for three years, so that, in a case of that kind, the first cost was not a serious matter. The cost could not be stated, as the life of the plate-and-quarl damper was still running.

DISCUSSION OF MR. SAM MAVOR'S PAPER ON "PRACTICAL PROBLEMS OF MACHINE-MINING."†

Mr. H. M. HOBART (London) wrote that, until the last few years, continuous-current motors were almost exclusively used for driving coal-cutters, and many manufacturers took up the standpoint that the polyphase motor could not be applied to such work. One leading reason related to the greater diameter,

* *Trans. Inst. M. E.*, 1906, vol. xxxi., page 163.

† *Ibid.*, 1906, vol. xxxi., page 378.

then considered to be a necessary attribute of a polyphase motor, as compared with the equivalent continuous-current motor. The difficulty, however, had proved to be far less formidable than these manufacturers believed, and amongst the machines which Mr. Mavor had described, a number were equipped with polyphase induction motors. It was important to emphasize the great advantage of low periodicity for such work. This might be explained as follows: A rotor-speed of not more than 750 revolutions per minute was generally preferred for such a motor; hence, when it must be operated from a 50-cycle circuit, it must have eight poles, whereas when operated from a 25-cycle circuit it has but four poles. Obviously, four-pole windings could be brought upon a much smaller periphery than eight-pole windings. Thus, for low-periodicity circuits, a much better design could be provided for a given limiting diameter.

There were a number of ways of approaching the problem of providing sufficient starting torque for a polyphase motor. When the motor was of the squirrel-cage type, there was the advantage of absolutely no moving contacts. But, on the other hand, any considerable amount of starting torque was, in a simple squirrel-cage motor, associated with a considerable rotor loss when running at constant speed: and, as a motor for coal-cutter purposes must be of the totally enclosed type, this comparatively great loss in the rotor circuits constituted a considerable disadvantage. Nevertheless, excellent results had been obtained with squirrel-cage coal-cutter motors, due largely to the intermittent nature of the work, which allowed a considerable time for the cooling of the motor.

A very promising way of meeting this question of providing considerable starting torque, and at the same time eliminating the large rotor loss, consisted in providing two squirrel-cage motors, preferably incorporated in a single casing. One of them, somewhat smaller than the other, was simply employed during the starting interval: it might, consequently, have a very high resistance in its rotor windings, and would, if run for any considerable length of time, attain a high temperature. Its purpose, however, was merely to run the machine up to speed against a high torque. After this operation was completed, the load was transferred to the second motor, and the first motor was cut out of the circuit. The squirrel-cage of the second

motor was proportioned with a very low resistance, and it would, consequently, have a negligible starting torque. During constant-speed running, however, its rotor losses were exceedingly small, and the temperature-rise was consequently smaller for the given overall dimensions. Such a motor could be a little smaller than the standard squirrel-cage motor customarily used for a coal-cutter machine, but there was the extra expense and extra space required for the starting motor, which was not very much smaller than the running motor. Nevertheless, the design was capable of being worked out very compactly, and with less overall height than was necessarily associated with a motor in which the starting and running properties were embodied in a single rotor.

A great variety of arrangements had been devised by various engineers for obtaining a good starting torque in polyphase motors, and, at the same time, avoiding the consequent large rotor loss during regular running. While many of them were too complicated to be adopted in such a case as a coal-cutter machine, where great strength and simplicity was an essential, several of the less complicated devices were well worthy of consideration in connection with the problem. The arrangement which he (Mr. Hobart) had previously described was, however, the simplest, and much might be said in its favour as a sound engineering proposition.

Continuous-current motors were largely free from these disadvantages with regard to starting; on the other hand, the commutator was by no means a desirable component of a coal-cutter motor, and the general favour with which polyphase motors had been received by mining engineers indicated that there was a large future for them in coal-cutting machinery.

Mr. T. E. Forster said that the description of the working of coal-cutting machines, and the opinions put forward, agreed very much with those recorded in the *Report of the Committee upon Mechanical Coal-cutting* of this Institute, but Mr. Mavor had had the advantage of bringing his information a great deal further up to date; and, if members had not already considered the paper, it was well worth looking into.

Dr. J. R. M. Robertson (Sydney, New South Wales) wrote that there appeared to be little necessity for Mr. Mavor to

deplore his want of mining experience in view of the thoughtful, well expressed, and sound manner in which he reasoned out the various mining problems that together have so close a bearing on the success of coal-cutting machinery. No exception could, he thought, be taken to the views enunciated in the laying-out of underground works suited to the conditions, and the reasons for so doing. So far from being a novice, Mr. Mavor possessed exceptional knowledge of exact mining, which few having long experience could approach. If mine-officials could in all cases be got to conduct operations on the sensible and correct lines that Mr. Mavor (an electrical engineer) so clearly laid down, a great step towards the more general use of coal-cutting machinery would be certain. The indifference or veiled hostility of some officials, towards adapting systems to new conditions, was in many cases the cause of the non-introduction of coal-cutting machinery.

In the general arrangement and distance between roads, the direction of the cutter-face relative to the cleavages of the coal and of the roof, Mr. Mavor in the main follows the admirable practice so clearly laid down by Mr. W. E. Garforth;* and little, he thought, could be said to improve upon these views. They appeared to embrace the whole of the questions that determined the success of coal-cutters, and there could be little doubt, with the advance of knowledge and the supervision of operations by educated go-ahead young engineers with exact ideas, that the prejudice that had in the past militated against machinery for under-cutting coal-seams would disappear, and the race would be as to which manager could in the least time adopt these and other labour-saving appliances.

In New South Wales, the hewing rates of coal-seams have been based on a standard height of seam worked by bords, 24 feet wide. Until recently, reduction on this standard was given in cases where bords were worked 36 feet in width for extracting pillars, while for longwall, a reduction equal to the sum paid for ripping or brushing and building was given. Recently, the Colonial Arbitration Court, in its great wisdom, swept away all such anomalies, and decreed that owners should pay the same rate for bords 36 feet wide as for 24 feet, and the same rate for longwall and for pillars. Further, it laid down the axiom that,

* "The Application of Coal-cutting Machines to Deep Mining," by Mr. W. E. Garforth, *Trans. Inst. M. E.*, 1902, vol. xxiii., page 312.

however worked, any coal-seam under 5 feet in thickness should be paid for by an addition (in the Southern district) of $\frac{1}{2}$d. per ton per inch to the standard rate. This rendered the working of the seams by hand impossible.

A large area of coal at Mount Kembla colliery being considerably under the standard height, and considered by the Arbitration Court unfit for miners to recover by ordinary methods, a resolution was passed to endeavour to recover the coal by means of machines. The coal-seam, in the portion selected as a trial, varied in thickness between 3 feet and 4 feet 4 inches. The coal is a steam coal and tender, it breaks in more or less columnar masses, and it has no very distinct cleavages. The floor is hard dark sandstone or fakes, the roof is dark and strong sandy bands, fakes or sandstone. It has very little dip and rise, gives off no water and an inappreciable amount of gas. The floor, however, is in parts crumpled into irregular rolls that begin at nothing, increase in size and again taper away. These are not frequent, nor in this district are they of large size: seldom more than 1 foot in height. There are no faults in the $\frac{1}{2}$ mile of face selected. These physical features were the factors that were considered in determining the selection of the machines. In the harder and higher coal of the Newcastle and Maitland districts, Ingersoll punching machines, Sullivan chain-breast coal-cutters and Jeffrey chain-breast cutters had been at work. None of these were considered adapted to the conditions, while disc machines, it was argued, would have a difficulty in getting over rolls in the floor, and it was thought that the coal-seam, when undercut, would fall and possibly jam the disc. After mature consideration, a medium-sized Pickquick machine was ordered, together with an experimental direct-current plant of 50 kilowatts at 500 volts to provide power for haulage, pumping and cutting machines. The armoured cables were laid one on each side of the main road, in a trench with the usual junction-boxes and face-cables. At first, the face was formed on the planes or facings of the seam. When the machine was ordered, the services of a competent mechanic were engaged from the makers. No difficulty was experienced at all with the machine, and, in the course of a few days, the men had mastered the working of it. To his (Dr. Robertson's) surprise, all the forebodings of difficulties disappeared as day and week passed without any

hitch occurring. To emphasize the statements of Mr. Mavor, the machine was started on a face parallel with the planes or facings of the coal. It was found that an undercut 4½ feet deep and the shaking of the machine brought the seam down in flakes. To avoid fitting, the machine cut in both directions; but it was found that when the bar cut in front these falls of coal often enveloped the machine, causing many delays. In the belief that this could be remedied by cutting more on end, by a series of short cuts, the face was wheeled round so as to cut half on end. This was an improvement, and by a continuance of the short cuts the cutting face was brought at right angles to the facings. By the use of a suitable carriage, instead of cutting in both directions, the machine now only cuts one way with the bar behind, and it is fitted for a contract price of 15s. per fit.

The miners being unaccustomed to the seam, and having successfully convinced the Arbitration Court that seams, 3 feet thick, were unfit for men to work in, to be consistent carried out this belief by a marked indisposition to work in this section. To facilitate filling, the roads were brushed and built up to 9 feet wide and spaced to 30 feet centres, but much difficulty has been experienced in obtaining fillers. This deficiency has caused many delays, and restricted the work of the machine. To remedy this, the use of face-conveyors was considered; but, considering the high rates paid for labour and the lower price received for Australian coal compared with that current in Great Britain, it did not seem possible even to adopt a simple form of conveyor of his own device. Meanwhile, the seam slightly increasing in thickness suggested a way out of the difficulty. A very light form of circular skip has been designed and built, standing 2 feet 8 inches high on wheels 12 inches in diameter, holding 15 cwts., and having a hollow scalloped-out at one end to permit of easy filling. This skip will be turned on a plate at each road-head and then pushed a few feet along the face, filled at the scalloped-out end, pushed back and headed when on the rails, and in this way the dearth of fillers will be surmounted, and by the avoidance of casting back the coal much breakage will be saved. The small coal made by the cutting-bar is very small; but that made by casting and breaking down the coal is of average size. At present, the proportion of small coal made exceeds that made from the thicker portions of the seam, but he (Dr. Robertson) was confident

of being able to reduce this by the new method suggested. Ordinary longwall worked by hand would give possibly a larger percentage of small coal. Gradually, the opposition and the general hostility of some of the workmen, not only to machines but to those who work them, are being worn down and will doubtless, in a short time, disappear.

Meanwhile, the face has been extended to a straight length of 1,350 feet, and a second machine has been obtained. The plan differs somewhat from that advocated by Mr. Mavor in that this face is worked from end to end with two machines, which, following each other, work about 750 feet distant, thus giving more time for filling. The roof gives little trouble. The small rolls in the floor when first struck wear down the pick-points, but no difficulty has been experienced in directing the bar and the machine itself over these irregularities. One machine has been working constantly for 15 months and the second for 3 months. Neither of these machines has caused any trouble whatever: there have been no breakdowns, and the repairs have practically been *nil*. Owing to inexperience, the machines at first received much rough usage. Contrary to the experience of others in New South Wales, who adopted American-made machines that have, as a rule, given great trouble and caused heavy expenditure for repairs, the machines at Mount Kembla colliery (being regularly examined and cleaned) have caused no stoppages, have had no breakdowns, and have incurred very little expense. Working at a distance of $\frac{3}{4}$ mile from the generator, they absorb an average of 11 to 12 horsepower, and cut from 17 to 21 inches per minute—one with a $4\frac{1}{2}$ feet undercut and the other with a $5\frac{1}{2}$ feet undercut. As a rule, the seam sags down from the roof when cut: but, occasionally, it requires a small shot to bring it down. The brushing is strong and is heavy to shoot, and possibly in course of time this expense may be somewhat reduced by increasing the distance between the gate-roads: but sufficient experience has been gained already to state that the heavy penalty imposed by the Arbitration Court can be saved by those who essay to work seams thinner than the arbitrary standard. The thin seams will be wrought by coal-cutters at possibly less cost than that paid for the thick seams, and then will realize all anticipations.

Naturally, having many unforeseen difficulties to overcome, the first machine has not produced the amount of coal that it will

from this time onwards, provided that the present conditions prevail; but, for the first year, with many short cuts and stoppages due to the coal being unfilled, etc., 23,000 tons were undercut, and a large increase on this is anticipated in the future.

The absence of any breakdowns is a tribute to the care and excellence of the workmanship and design of the Pickquick machine, which should be known to those who delay introducing machines, because of the fear of trouble from breakages that have certainly been in this case conspicuous only by their absence. In some of the Newcastle collieries, where the character of the coal-seam and the conditions are entirely different, the owners would have a wider range of machines to choose from to do their undercutting; but, so far as he had proceeded, he thought that for the conditions in the South, he could have selected no machine that would have so well fulfilled the requirements, or one that would have given so little trouble.

In respect to the renewal of picks, these are changed as a rule once in a shift, and this is not a lengthy or a difficult operation; but he had always held, and had expressed this to the makers, that by adopting some of the many special steels now on the market, picks could be produced that would give much better results. Some weeks ago, a friend, who had Sullivan machines at work in a very hard coal-seam, complained of the frequent necessity of changing the pick-points. He accepted the offer of a set of pick-points, free for a trial, made of Bowler steel, with the result that, whereas he was formerly obliged to change these every third bord, 28 bords were now cut, and then they were in a better condition than the steel supplied by the makers of the Sullivan machine, after cutting the smaller number of bords. He intended to try this steel in the Pickquick machine, whenever he had dies cut to stamp them, and he hoped to effect a similar improvement.

Finally, his experience of long straight faces exactly bore out the statements of Mr. W. E. Garforth: larger coal is produced, and the face is more easily managed, with all the advantages of this improved method of working.

The further discussion was adjourned.

Mr. T. A. O'Donahue's paper on "The Valuation of Mineral Properties" was read as follows:—

THE VALUATION OF MINERAL PROPERTIES.

By T. A. O'DONAHUE.

I.—Discounting Deferred Values.

Introduction.—The writer's primary object, in submitting this paper to the members, is to call attention to the rules usually adopted for discounting deferred values. The absurdly low present values given by tables calculated at compound interest, when high remunerative rates of interest are necessary and the deferred period exceeds a few years, induced the writer to investigate the matter, and he concluded that the customary method of determining the present value was not sound. Were it not that the writer's independent conclusions appeared to agree with those laid down by an eminent actuary, he would have had some hesitation in presenting his views. He has thought it desirable to give, at the same time, a résumé of the subject generally.

The valuation of a mine or a mineral estate presents unusual difficulties as the special risks to which the revenue are subject and the peculiar character of the property necessitates the application of certain principles not common to the valuation of other properties. The work which a mining engineer, engaged on a valuation, has to perform is twofold: the first part depends for its worth on the ability and experience of the engineer, and the second part on the accuracy of the actuarial principles applied to determine the value.

General Procedure.—The valuer first estimates the annual revenue that may be derived from the property, and the number of years during which this revenue may be expected to be realized. He next decides upon the rate of interest, which, after due regard to the character of the property, he considers a suitable return for the risk, and then he is in a position to estimate the present value. It follows that, at the end of the term of years fixed for revenue, a mineral estate may be taken as value-

less. A colliery may be treated practically in the same manner, for the plant at breaking-up prices cannot have much present value; and apart from this there are usually obligations to be performed on the termination of the lease, such as the restoration of the surface and other lessee's covenants, and this may be left to cover them. Should, however, the engineer consider that the plant at the end of the term would have an appreciable value in excess of the obligations due to the lessor, the present value of such sum must be calculated and taken into consideration in the purchase money.

Redemption of the Principal.—In estimating the present value, it is necessary that the annual revenue should be such as not only to afford the specified interest on the principal, but such additional sum as will enable a purchaser to redeem his original capital. The amount to be reinvested should be large enough to redeem the principal, by a safe investment, which would yield an absolutely certain income as a trust security, and should not be calculated at the high rate of interest, which the risk of a mineral property necessitates for reasonable investment.

Accumulative and Remunerative Rates of Interest.—The positive accumulative rate of capital is fixed by the increments due to the interest that can be obtained from an investment, in which the principal and interest are absolutely secure. Theoretically no such security exists; but, for practical purposes, the accumulative rate may be taken to be that rate which may be realized with the greatest possible security. The accumulative rate is not constant, and, like other things, it is influenced by the law of supply and demand.

When it is necessary to grant greater profits for the use of capital than the accumulative rate, it is because the capitalist is of opinion that there is some element of risk, and the additional profit is bargained for as insurance. Theoretically the profits from an infinite number of speculative transactions should be, and in practice would be found to be, approximately equal to the accumulative rate obtainable from first-class securities. A writer* recently estimated that the net profit on coal-mining in

* "Wages and Profits in the British Coal-trade," by Mr. T. Good, *Cassier's Magazine*, 1906, vol. xxix., page 370.

this country, calculated over a long period of years, was not more than 3 per cent., after allowing for redemption of capital. He supported his statement by more or less authoritative figures, and while his estimate of profits was perhaps low, the error must be small.

The rate of interest to be calculated as the basis of a speculative transaction is divisible into two parts:—(1) Interest at the accumulative rate, which is the actual earning power of the principal; and (2) interest or insurance for the risk taken. It follows, therefore, that a speculation which yields anything greater than this accumulative rate has been successful, no matter how much it falls short of the rate calculated as the basis of the purchase.

The remunerative rates of interest adopted for the valuation of mineral properties vary between wide limits. For coal-mines in this country, the rate of interest generally ranges from 6 to 15 per cent. A thorough knowledge of the circumstances and experience of similar transactions can alone enable the mining engineer to fix, with any degree of accuracy, the rate of interest on which he should base his calculations so as to obtain equitable results.

Valuation of Mineral Estates.—Frequently a valuation has to be made on the slenderest foundation, and it is not surprising if the estimate be often very wide of the realized price. Take the case of a mineral estate, which can only be worked to a profit by an adjoining colliery. The gross royalty value of the minerals at current prices can be estimated with more or less accuracy; but, if a revenue be not assured by a lease of the mines to the colliery company, an estimate based on a probable prospective revenue may be entirely at fault. Competition generally decides the value of a commodity; but, in this case, there is practically no competition, the ultimate purchaser of the coal must be the colliery company, and they must be depended upon for the revenue. It is, therefore, in their power to dictate terms; and, in the event of these being refused, they can render the estate valueless by leaving the minerals unworked. It is improbable that such an extremity would be resorted to, for if the mines were offered on reasonable terms it would be to the interest of the colliery owners to accept them.

But what is more frequently done, when a difficulty about terms arises, is to defer the working of the mines for some time, and, as a consequence, to depreciate their present value. A valuation under such circumstances cannot claim to be precise: but this objection applies more or less to all valuations based on high remunerative rates of interest, for the use of a high remunerative rate presupposes uncertainty as to the realization of profits.

Valuation of Collieries.—To form an opinion upon the value of a colliery, the engineer requires an estimate of (*a*) the total quantity of workable coal available, (*b*) the annual output, (*c*) the annual profits, (*d*) the value of the plant, etc., at the end of the term, and (*e*) the cost of fulfilling all obligations at the end of the term. Innumerable points arise for consideration before any satisfactory estimate can be made. To obtain the total quantity of coal available for sale, proper allowance must be made for colliery-consumption, faults, barriers and pillars which will be required to be left for support: all seams must be included, which it is thought may be workable to a profit during the term, although it may be deemed advisable to divide the total life of the colliery into two or more periods, so as to differentiate the profits according to the quality of the seams likely to be worked in each period, and the probable cost of getting. The estimate of the annual output may be conditional on the expenditure of a certain sum in development, and this must be allowed for when determining the present value of the colliery. The most important estimate, and the one which it is most difficult to fix, is the profit per ton from which to determine the annual profits. To the ordinary working costs, which must be decided by a consideration of the several seams, must be added the cost of supervision, stores, maintenance of plant, royalties, wayleaves, rates, insurance, compensation for surface-damage, etc. To eliminate as much as possible abnormal conditions caused by fluctuations in trade, the selling prices should be based on the average prices realized over a number of years. The total output must be divided into round and small, in the proportion which the characteristics of the seams appear to dictate, so as to obtain the average selling price. The present value of the breaking-up value of the plant must be calculated, and against this must be set the cost of restoring the surface,

royalty payments on abandoned coal, and other costs incidental to winding up.

The original capital may be reduced by the amount recoverable at the end of the term to ascertain the sum which has to be redeemed by the sinking fund; or a sinking fund may be allowed for, large enough to redeem the original capital, and the present value of the recoverable capital may be calculated at a practicable rate of interest. Theoretically, the latter method would be more advantageous to a purchaser, for the sinking fund would be taken at an accumulative rate of interest and the present value of the recoverable capital would be taken at a slightly higher rate. In practice, however, there would be little difference, for the valuer would be inclined to estimate the recoverable capital at the minimum, if it were accounted as redeemed capital; and would make a more generous estimate if it were to rank as profits.

Discounting Deferred Values.—In the case of a mineral estate from which there is no immediate revenue, the engineer, with a knowledge of the circumstances, forms an estimate of the period which must elapse before revenue commences; and, having fixed the probable annual revenue and its term, calculates the present value on the basis of a deferred annuity. This method is generally followed, but there appears to be a diversity of opinion as to how the interest accumulating during the deferred period should be calculated. The general custom appears to be to base the valuation on the principle that compound interest, at the high rate stipulated for the purchase, should be allowed during the deferred period; and that interest at the high rate should be allowed during the period of revenue on the amount thus accumulated. This stipulation, in the writer's opinion, is erroneous, and cannot be accepted as yielding equitable results. The purchaser of a deferred annuity must be placed in no better and in no worse position than if his purchase were an immediate annuity. The method given above puts a purchaser in a much better position, as is obviously shown when the remunerative rate of interest is high and the deferred period is a long one.

To take the problem in its simplest form, say it is required to find the present value of a sum of money due some years hence. If the rate of interest agreed upon as the basis of

the transaction be what may be termed a "practicable" rate, the present value should be such as would accumulate at compound interest, at the end of the deferred period, to the money due. Should, however, a high rate of interest be stipulated, the purchaser anticipates interest at that rate on his principal, but the accumulations of interest cannot be expected to acquire interest at the high rate: because the interest is not capital risked by the purchaser, and is therefore not entitled to insurance, but should acquire interest at a practicable rate.

It may be argued that it is entirely a matter of arrangement; and that the purchaser, knowing the method to be adopted, stipulates for a remunerative rate of interest accordingly. Practically, if the parties to the transaction were able to accurately gauge the conditions, so as to afford comparison with some standard, it would be of no great consequence which method was adopted. The writer, however, is of opinion that to stipulate for compound interest, at a high remunerative rate, is illogical; and that it affords no true basis for comparison and is misleading.

Say, a purchase is made on a 10 per cent. basis. Taking the purchase money as £100, if the investment proves as successful as is anticipated and the interest is realized annually, the purchaser obtains a profit of £10 each year. He may use the profits to purchase gilt-edged securities, in which case he would obtain, say, 3 per cent. on them: or he may speculate again for a 10 per cent. rate of interest. If the second course were followed and proved successful, he would have obtained 10 per cent. compound interest on his principal over the whole of the period. To do this, however, he has had to speculate a second time, and accept the risks of both the first and the second operation. To presuppose a second speculation, without accompanying risk, is illogical; and, further, a second speculation cannot be admitted in the calculation of the first. The profits must be assumed to accumulate at a rate of interest such as could be safely secured.

The problem may be considered in another way: taking the accumulative rate of capital at 3 per cent., the purchase made on a 10 per cent. basis calculates for 7 per cent. as insurance to cover risk. Again, taking £100 as the purchase money, the accumulative value of the capital at the end of one year is £103. If it be assumed that no interest is realized during the first

year, but that the transaction is successfully closed at the end of the second year, the purchaser is entitled to 10 per cent. interest during the second year on the accumulative amount of his principal, that is to say, 10 per cent. on £103, together with the £10 due for the first year, or, in all, including principal, £120·3: but if interest be paid at the high rate on the accumulative amount of the principal during the second year he is not entitled to any interest on the £7, the amount of the insurance to cover the risk. The purchaser risks the amount of the principal at the accumulative rate, but the £7 is part of the money for which he has speculated, and, whether the purchaser obtains the whole or part of it, depends upon the success of the speculation. It cannot be assumed that this money ranks as capital and is invested in the speculation.

If a man effect a speculation which is to be closed on the same day, his possible loss is limited to his purchase money; and it would be absurd to allow him to increase his shares, in the event of the speculation being successful, by adding to it any portion of the money gained in the speculation. Similarly, the £7 is not money risked, nor is it part of the natural accumulative value of the principal; and to calculate interest at the high rate on this amount would be equivalent to giving the purchaser the option of increasing his shares if the speculation were successful, while limiting his losses in the event of failure.

The investor must increase his holding to the extent of the natural increase of the capital at the accumulative rate, but it is not logical to assume that the extra interest, for which the speculation is made, can be invested in the transaction to acquire interest at the remunerative rate. Whether the calculation be based on the assumption that the profits are realized annually during the deferred period and invested to acquire interest at the accumulative rate, or that the remunerative rate of interest is to be allowed on the amount of the capital increased at the accumulative rate, is immaterial, as both methods are logical and the results are identical. The former method is the way in which the problem is viewed by Mr. George King,* who appears to consider it as axiomatic that the profits must be calculated as accumulating at the lower rate of interest. A consideration of the operations of the fund by each method for a number of years will be instructive.

* *The Theory of Finance*, by Mr. George King, third edition, 1898, page 38.

Let it be required to find what sum should be paid four years hence in consideration of a present advance of £100, the remunerative rate of interest being 10 per cent. and the accumulative rate 3 per cent.

(*a*) By the first method, taking the profits as accumulative:

Principal		£100·00000
First year's interest		10·00000
Second year's interest:		
10 per cent. on the principal	£10·00000	
3 per cent. on the previous year's interest ...	0·30000	
		10·30000
Third year's interest:		
10 per cent. on the principal	£10·00000	
3 per cent. on the accumulated interest, £20·30000	0·60900	
		10·60900
Fourth year's interest:		
10 per cent. on the principal	£10·00000	
3 per cent. on the accumulated interest, £30·90900	0·92727	
		10·92727
The amount due at the end of four years being		£141·83627

(*b*) By the second method, taking the accumulative amount of the principal and allowing interest at the remunerative rate on that amount:

Principal	£100·00000
First year's interest	10·00000
Second year's interest: 10 per cent. on the accumulative amount of the principal, £103	10·30000
Third year's interest: 10 per cent. on the accumulative amount of the principal, the amount of £100 at 3 per cent. for two years or £106·090000	10·60900
Fourth year's interest: 10 per cent. on the accumulative amount of the principal, the amount of £100 at 3 per cent. for three years or £109·2727	10·92727
The amount due at the end of four years being	£141·83627

If compound interest at 10 per cent. were allowed throughout the term, the amount due would be £146·41. The difference in this case is not great, but it increases rapidly with the length of the term.

Definitions.

Interest.—Interest is the remuneration paid for the use of capital. The rate of interest is the ratio between the interest and the principal or capital invested. In commercial trans-

actions, the interest is generally stated in rate per cent, but for mathematical calculations it will be found to facilitate operations if the interest be converted to rate per unit. Whereas the commercial custom is to give the interest on 100, the interest is required on unity: and the rate per cent. must, therefore, be divided by 100 to obtain the rate per unit. The sum of any principal and its interest together is called the amount.

If the interest on a loan be calculated on the principal only, for the whole time of the loan, it is said to be simple interest. If the principal be increased at fixed periods by the interest then due, and the interest for each succeeding period be calculated on the original principal together with the previous accumulations of interest, it is termed compound interest.

Unless otherwise stated, the unit of time for the calculation of interest is one year, and when compound interest is stipulated for, the interest is convertible, that is to say, it is added to the principal each year. Strictly speaking there is no such thing as simple interest, for interest due must have an accumulative value. What is meant, when simple interest is made a conditional term of a loan, is that the period at which interest becomes convertible is for some longer period than one year. In such a case the annual rate of interest is stated, but it is the nominal rate of interest that is given and not the effective rate. Thus, if the conditions of a loan were 5 per cent. per annum simple interest for three years, the 5 per cent. is the nominal rate of interest and it would be more correct to say that the rate of interest was 15 per cent. per three years, the word "simple" being deleted. Similarly, it frequently happens that a loan is made for compound interest with the condition that the interest is to be convertible at shorter periods than one year. In such a case, the nominal rate of interest per annum is less than will be actually realized. Thus, say, the conditions of a loan are 5 per cent. per annum and the interest is to be paid half-yearly, here 5 per cent. is the nominal rate of interest, for if half a year's interest be paid each half year, the actual interest paid is greater than 5 per cent. per annum: for the first half year's payment of interest in any one year may be invested, and interest acquired thereon during the second half of the year. The conditions would have been more correctly stated by fixing the rate of interest as $2\frac{1}{2}$ per cent. per half year.

For purposes of distinction, the rate of interest which can be obtained on capital invested with a minimum of risk is termed the accumulative rate, and when a higher rate of interest is stipulated to cover risk it is termed the remunerative rate.

Annuities.—An annuity is a periodical payment amounting to a certain annual sum. The term or status of an annuity may be a fixed number of years, when the annuity is termed certain, or for an uncertain period to be determined by a particular event. An annuity that is to be paid indefinitely is termed a perpetuity.

The first payment of an annuity payable annually is assumed to become due at the end of the first year for which the annuity is made, and in the case of a deferred annuity, payable annually, the first payment is assumed to become due one year after the period of deferment. Similarly, if the payments of an annuity have to be made at more frequent intervals than one year, the first payment is assumed to become due at the end of the first period of the term for which the annuity is made.

If it be required that the first payment of an annuity be payable at the beginning of the term, it is called an annuity due.

Redemption or Sinking Fund.—The terms of purchase of an annuity certain must be such that the annuity will provide not merely interest on the outlay at the stipulated rate, but also such additional sum, as will, if invested as obtained, amount to the principal at the end of the term. The amount which must be periodically set aside to redeem the principal is termed the sinking or redemption fund.

No matter what may be the rate of interest, for which a purchaser of an annuity stipulates to cover risk, the sinking fund must be large enough to ensure the principal being redeemed with the least possible risk, and the rate of interest at which the sinking fund must be assumed to accumulate must, therefore, be not greater than can be realized from a safe investment.

When the rate of interest stipulated as the conditions of purchase of an annuity is greater than the rate at which the redemption fund can be assumed to accumulate, it is usual to allow interest at the stipulated rate on the principal or purchase money during the whole of the term of the annuity, despite the

fact that a portion of the principal is redeemed each year of revenue. Theoretically, the annuity should provide interest at the stipulated rate on the outstanding capital only. As, however, a purchaser makes his bargain on the assumption that the annuity will provide interest at the specified rate on his original outlay during the whole of the term, this is the principle adopted in the formulæ and is the one universally accepted.

Rules and Examples.

I.—*The amount of £1 in n years.*—If the principal be £1 and the interest be at the rate of r per £ per annum, the amount to which the principal accumulates in one year will be $1+r$, and if this amount be invested for another year at the rate r, its amount at the end of the second year will be $(1+r)(1+r)$ or $(1+r)^2$; and, generally, £1 invested at the rate r, compound interest, for n years, will amount to $(1+r)^n$.

Where r is the rate of interest, or interest on 1, or rate per cent. divided by 100; n, the term of years: and R^n, the amount of 1 in n years at the rate r: then: $R^n=(1+r)^n$ . . . (1)

(*a*) *Example.*—What is the amount of £1,000 in eight years at 4 per cent. compound interest? The rate, r, equals 4 divided by 100 or 0·04; and the amount of 1 equals $(1+0{\cdot}04)^8$ or $1{\cdot}04^8$ or 1·368569. The amount of £1 at 4 per cent. in eight years is consequently £1·368569, and the amount of £1,000 is £1,368·569.

If the interest is to be calculated for a unit of time other than one year: that is to say, if the interest is to be convertible at greater or less frequent periods than one year, the same principle holds. Thus, say, the interest is realized m times per year, the interest for each unit of time being r/m (where r is the nominal rate of interest for a year). Then the amount of £1 in one year is $\left(1+\frac{r}{m}\right)^m$, and the amount of £1 in n years is $\left(1+\frac{r}{m}\right)^{mn}$. (1*a*)

(*b*) *Example.*—What is the amount of £1,000 in eight years at 4 per cent. per annum, the interest being convertible half-yearly? It should be noted that 4 per cent. per annum is the nominal rate of interest, the actual rate of interest being 2 per cent. per half year. The rate, r, equals 0·04, m is 2, and $\frac{r}{m}$ is 0·02. The amount of £1 for eight years is $(1+0{\cdot}02)^{2\times 8}$ or $1{\cdot}02^{16}$, and $1{\cdot}02^{16}$ equals 1·372785. The amount of £1 in eight years is £1·372785, and the amount of £1,000 in eight years is £1,372·785.

It is obvious that 4 per cent. per annum, convertible half-yearly for eight years, amounts to the same as 2 per cent. per year for sixteen years.

II.—*The amount of £1 per annum in n years.*—As the first payment of an annuity becomes due at the end of the first year, the amount of an annuity of 1 at the end of the first year is 1; at the end of the second year, the annuity amounts to $1+(1+r)$; at the end of the third year, to $1+(1+r)+(1+r)^2$; and, generally, the amount of the annuity of 1 in n years equals $1+(1+r)+(1+r)^2 \ldots + (1+r)^{n-1}$ equals $\frac{(1+r)^n-1}{r}$.

Where r is the rate of interest or interest on 1; and R^n, the amount of 1 in n years at the rate r or $(1+r)^n$; then the amount of 1 per annum in n years equals $\frac{R^n-1}{r}$ . . . . . (2)

a) *Example.*—What is the amount of £100 per annum in eight years at 4 per cent? The rate, r, is the interest on 1, or 4 divided by 100 equals 0·04. The amount of 1 equals $\frac{1{\cdot}04^8-1}{0{\cdot}04}$. As before, $1{\cdot}04^8$ equals 1·368569. The amount of 1 equals $\frac{1{\cdot}368569-1}{0{\cdot}04}$ equals $\frac{0{\cdot}368569}{0{\cdot}04}$ or 9·214225: and the amount of £100 per annum equals £921·4225.

If the annuity be payable by equal instalments m times in a year, and the interest be convertible at the same intervals: r being the nominal rate of interest per annum, and m, the number of times per annum that the interest is convertible, then the amount of £1 per annum equals $\frac{\left(1+\frac{r}{m}\right)^{mn}-1}{r}$ . . . . . (2*a*)

(*b*) *Example.*—What is the amount of an annuity of £100 payable half-yearly in eight years at 4 per cent? The amount of 1 equals $\frac{\left(1+\frac{0{\cdot}04}{2}\right)^{2\times 8}-1}{0{\cdot}04}$ equals $\frac{1{\cdot}02^{16}-1}{0{\cdot}04}$ or $\frac{1{\cdot}372785-1}{0{\cdot}04}$ or 9·31965. The amount of 1 is 9·31965 and the amount of £100 is £931·965.

III.—*The present value of a perpetuity.*—A principal of 1

invested at the rate, r, will yield an annuity of r indefinitely. Therefore the value of a perpetuity of 1 is $\frac{1}{r}$ . . . . (3)

The value of a perpetuity of 1 at 4 per cent. is 1 divided by 0·04 or 25.

IV.—*The value of a deferred perpetuity.*—A principal of 1 invested at the rate, r, will amount in n years to R^n; and if this be invested it will yield $r \times R^n$ indefinitely.

Therefore, where r is the rate of interest or the interest on 1 for one year; n, the number of years that the perpetuity is deferred: and R^n, the amount of 1 in n years at the rate r, or $(1+r)^n$: then the value of a perpetuity of 1 deferred n years is $\frac{1}{r \times R^n}$. (4)

(*a*) *Example.*—What is the value of a perpetuity of £10 deferred four years at 4 per cent? The rate, r, equals 4 divided by 100, equals 0·04: and R^n equals $1{\cdot}04^4$ or 1·16986. The value of a deferred perpetuity of £1 is $\frac{1}{0{\cdot}04 \times 1{\cdot}16986}$ or $\frac{1}{0{\cdot}0467944}$ or 21·3701; and the value of a deferred perpetuity of £10 is £213·701.

V.—*The present value of £1 due n years hence.*—It has been shown that a principal of 1 invested at the rate, r, for one year amounts to $1+r$; and, consequently, 1 is the present value of $1+r$ due one year hence. Therefore the present value of 1 due a year hence is $\frac{1}{1+r}$. Similarly, as $(1+r)^n$ is the amount of 1 in n years, it follows that 1 is the present value of $(1+r)^n$ due n years hence.

Where r is the rate of interest or the interest on 1 for one year: n, the term of years; and R^n, the amount of 1 at the rate, r, in n years, or $(1+r)^n$; then the present value of £1 due n years hence is $\frac{1}{(1+r)^n}$ or $\frac{1}{R^n}$ . . . . . (5)

(*a*) *Example.*—What is the present value of £600 due eight years hence, at 4 per cent. per annum? The rate, r, equals 4 divided by 100 or 0·04. The present value of £1 equals $\frac{1}{(1+0{\cdot}04)^8}$ or $\frac{1}{1{\cdot}04^8}$ or $\frac{1}{1{\cdot}368569}$ or 0·73069; and the present value of £600 is £438·414.

The above rule is correct only when the rate of interest taken as the basis of the calculation is approximately the accumulative rate. If the nature of the transaction be such that a high rate of interest has to be allowed for remuneration, the rule ceases to give equitable results. The principle on which the calculation must be based is to place the purchaser of the deferred payment in the same position at the end of the term as that in which he would be if he had invested his capital in operations involving the same element of risk as the deferred payment and yielding interest annually. Assuming that such operations were successful, he would have realized the remunerative rate of interest on his capital each year, and these profits could be invested as obtained, so as to increase at an accumulative rate.

If s be the remunerative rate of interest and r the accumulative rate, the amount of s per annum in n years, by rule (2) is $s \times \frac{R^n - 1}{r}$. Taking the principal as unity, to find the amount of the principal, under these conditions, 1 must be added to the amount of the interest. Thus the amount of 1 in n years is $1 + s \times \frac{R^n - 1}{r}$. The reciprocal of this expression gives the present value of 1 due n years hence. Therefore, where r is the accumulative rate of interest: s, the remunerative rate of interest; R^n, the amount of 1 in n years at the rate r or $(1+r)^n$; then the present value of 1 in n years is

$$\frac{1}{1 + s \times \frac{R^n - 1}{r}} \quad . \quad . \quad . \quad . \quad . \quad (6)$$

(b) Example.—What is the present value of £1,000 due twelve years hence, allowing a purchaser 10 per cent. on his outlay, and accumulating the interest at 3 per cent? The remunerative rate of interest s is 10 divided by 100 or 0·10; the accumulative rate of interest, r, is 3 divided by 100 or 0·03; R^n equals $1{\cdot}03^{12}$ or 1·42576. The present value of 1 is $\frac{1}{1 + 0{\cdot}1 \frac{1{\cdot}42576 - 1}{0{\cdot}03}}$ or $\frac{1}{1 + 1{\cdot}4192}$ or 0·41336; and the present value of £1,000 is £413·36.

VI.—*Redemption or sinking fund.*—The rule (2) gives the amount of £1 per annum in n years, hence the reciprocal of that expression will give the fund which must be invested at the rate r to amount to 1 in n years.

Where r is the interest on 1: and R^n is the amount of 1 in n years or $(1+r)^n$; then the redemption fund per annum that will amount to 1 in n years is $\frac{r}{R^n-1}$ . . . . . (7)

(*a*) *Example.*—What redemption or sinking fund must be invested annually at 3 per cent. to redeem £200 in 20 years? The amount R^n equals $1{\cdot}03^{20}$ or 1·806111. The redemption fund for 1 is $\frac{0{\cdot}03}{1{\cdot}806111-1}$ or 0·037216: and the redemption fund for £200 is £7·4432.

Should the interest on the redemption fund be invested m times per annum, and the interest be convertible m times per annum, the reciprocal of the rule (2*a*) must be applied. The redemption fund per annum, the interest being convertible m times per year, is $\frac{r}{\left(1+\frac{r}{m}\right)^{mn}-1}$ . . . . . (7*a*)

(*b*) *Example.*—What annual sinking fund will amount to £200 in 20 years at 3 per cent.; the sinking fund being invested half-yearly, and the interest being convertible at the same intervals? The sinking fund for 1 is $\frac{0{\cdot}03}{\left(1+\frac{0{\cdot}03}{2}\right)^{20\times 2}-1}$ or $\frac{0{\cdot}03}{1{\cdot}015^{40}-1}$; $1{\cdot}015^{40}$ equals 1·814018; and $\frac{0{\cdot}03}{1{\cdot}814018-1}$ equals $\frac{0{\cdot}03}{0{\cdot}814018}$ or 0·036854. The sinking fund per annum to produce £200 is therefore £7·3708.

VII.—*The present value of an annuity.*—The amount of an annuity of 1 in n years was shown by rule (2) to be $\frac{R^n-1}{r}$. The present value of such an annuity must be such a sum as would, if invested at the rate, r, for n years, be equal to the amount of the annuity. Taking the present value as P, the amount of P at the rate, r, in n years equals $P\times R^n$; and $P\times R^n$ equals $\frac{R^n-1}{r}$.

Where r is the rate of interest, or interest on 1 for one year: n, the term of years: and R^n, the amount of 1 at the rate r in n years, or $(1+r)^n$: then the present value of the annuity, P, equals $\frac{R^n-1}{R^n\times r}$ . . . . . (8)

(*a*) *Example.*—What is the present value of an annuity of

£100 for eight years, allowing interest at 3 per cent? The rate, r, equals 3 divided by 100 or 0·03; and R^n equals $1{\cdot}03^8$ or 1·26677. The present value of an annuity of 1 is $\frac{1{\cdot}26677-1}{1{\cdot}26677\times 0{\cdot}03}$ or $\frac{0{\cdot}26677}{0{\cdot}0380031}$ or 7·0197: and the present value of an annuity of £100 is £701·97.

In the rule given above, the redemption fund is assumed to accumulate at the same rate of interest as is calculated on the principal. When a high rate of interest is taken as the remunerative rate on the principal, the rule will not apply, as the redemption fund could not be invested with safety to acquire interest at the same rate. Under such circumstances, it is necessary, therefore, to assume that the redemption fund accumulates at another and lower rate of interest.

Taking the present value of an annuity as P and the remunerative rate of interest allowed on the principal as s, the annuity must be such as will yield $P\times s$: and, in addition, a sufficient sum for the redemption fund such as will redeem the principal at a lower rate of interest, r. The redemption fund that will redeem P in n years was shown by rule (7) to be $P\times\frac{r}{R^n-1}$. Therefore, the annuity, P equals $\left(\frac{r}{R^n-1}+s\right)$: and for an annuity of 1, where s is the remunerative rate of interest on the principal; r, the rate of interest on the redemption fund: n, the term of years: and R^n, the amount of 1 in n years at the rate r, or $(1+r)^n$: then the present value, P, equals

$$\frac{1}{\frac{r}{R^n-1}+s} \qquad . \quad . \quad . \quad . \quad . \quad . \quad (9)$$

(*b Example.*—What is the present value of £100 per annum for twelve years, allowing interest on capital at 8 per cent.: the redemption fund being assumed to accumulate at 3 per cent? The remunerative rate of interest is 8 per cent., and s equals 0·08: the accumulative rate of interest is 3 per cent. and r equals 0·03; the present value, P, of an annuity of 1 equals $\frac{1}{\frac{0{\cdot}03}{1{\cdot}03^{12}-1}+0{\cdot}08}$: and $1{\cdot}03^{12}$ equals 1·42576. Therefore, the present value of an annuity of 1 is $\frac{1}{\frac{0{\cdot}03}{1{\cdot}42576-1}+0{\cdot}08}$, or 6·6462; and the present value of an annuity of £100 is £664·62.

If the annuity be payable by equal instalments m times per year, and the interest be convertible at like intervals; where s is the nominal remunerative rate of interest per annum; r, the rate of interest per annum on the redemption fund; n, the term of years; and m, the number of times per annum that the instalments of the annuity are payable and the interest on the redemption fund is convertible, the present value of an annuity of 1 is

$$\frac{1}{\frac{r}{\left(1+\frac{r}{m}\right)^{mn}-1}+s} \quad . \quad (9a)$$

(*c*) *Example.*—What is the value of an annuity of £100 for eight years, payable half-yearly, allowing a purchaser 10 per cent. interest and redeeming the principal at 4 per cent., interest on the redemption fund being convertible half-yearly? The rate, s, equals 10 divided by 100, or 0·10; r equals 4 divided by 100, or 0·04: m equals 2: $\frac{r}{m}$ equals $\frac{0{\cdot}04}{2}$ or 0·02; and $1{\cdot}02^{16}$ is 1·372786. The present value of an annuity of 1 is $\frac{1}{\frac{0{\cdot}04}{(1+0{\cdot}02)^{2\times 8}-1}+0{\cdot}10}$, or $\frac{1}{\frac{0{\cdot}04}{1{\cdot}372786-1}+0{\cdot}10}$, or $\frac{1}{0{\cdot}107300+0{\cdot}10}$, or 4·82392; and the present value of an annuity of £100 is £482·392.

An examination of the operations of the fund will show more clearly what the calculation allows. To redeem a principal of 1 by half-yearly investments at 4 per cent., with the interest convertible half-yearly, requires an annual sinking fund of $\frac{0{\cdot}04}{(1+0{\cdot}02)^{2\times 8}-1}$, or 0·107300. The redemption of the purchase money requires a sinking fund of $482{\cdot}392\times 0{\cdot}107300$, or £51·76076: the provision of 10 per cent. interest on the purchase money requires £48·2392: making a total of £99·99996. The annuity of £100 therefore meets these conditions. It should, however, be noted that the £48·2392 provided by the annuity as interest on the principal, is payable by half-yearly instalments, therefore the actual rate of interest is 5 per cent. per half year, an effective rate of rather more than 10 per cent. per annum. The 10 per cent. is the nominal rate of interest, and is so defined in the formula.

VIII.—*The present value of a deferred annuity.*—As has been previously stated, when a high rate of interest is allowed on the

principal, the payments of the interest must be assumed to accumulate at another and lower rate. Where P is the present value of an annuity of 1, the amount of P and its accumulated interest at the end of a term of n years is $P\left(1+s\times\frac{R^n-1}{r}\right)$, where s is the remunerative rate of interest and r the accumulative rate of interest. The amount of an annuity of 1 for n years at the rate r was shown by rule (2) to be $\frac{R^n-1}{r}$. The amount of the principal and its accumulated interest at the end of the term should be equal to the amount of the annuity; and, consequently, $P\left(1+s\times\frac{R^n-1}{r}\right)$ equals $\frac{R^n-1}{r}$. This equation can be shown to be identical with the equation (9), giving the present value of an immediate annuity, which is as it should be, as the amount of the principal has been taken for exactly the same period as the term of the annuity. The problem which is under present consideration, however, is that of a deferred annuity, and if d be the period of deferment the expression becomes $P\left(1+s\times\frac{R^{n+d}-1}{r}\right)$ equals $\frac{R^n-1}{r}$; where s is the remunerative rate of interest; r, the accumulative rate of interest: n, the term of the annuity: d, the term of deferment; R^n, the amount of 1 in n years at the rate r, or $(1+r)^n$; and R^{n+d}, the amount of 1 in $n+d$ years at the rate, r, or $(1+r)^{n+d}$; then the present value, P, of a deferred annuity of 1 is

$$\frac{\frac{R^n-1}{r}}{1+s\times\frac{R^{n+d}-1}{r}} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (10)$$

(a) *Example.*—What is the present value of £100 per annum for twenty years, deferred 10 years, allowing a purchaser 15 per cent. on his outlay, and redeeming the purchase money at 3 per cent; the interest during the deferred period being assumed to accumulate at 3 per cent? The rate, s, equals 15 divided by 100 or 0·15: r equals 3 divided by 100 or 0·03; $1{\cdot}03^{20}$ equals 1·806111: and $1{\cdot}03^{30}$ equals 2·427262. The present value of 1 is

$$\frac{\frac{1{\cdot}03^{20}-1}{0{\cdot}03}}{1+0{\cdot}15\frac{1{\cdot}03^{20+10}-1}{0{\cdot}03}} \text{ or } \frac{\frac{1{\cdot}806111-1}{0{\cdot}03}}{1+0{\cdot}15\frac{2{\cdot}427262-1}{0{\cdot}03}} \text{ or } \frac{26{\cdot}87037}{8{\cdot}13631} \text{ or } 3{\cdot}3025;$$

and the present value of £100 per annum is £330·25.

To show clearly the principle on which the formula has been constructed, the writer will assume that £330·25 has been invested under the conditions stated, and he will show that the operation of the annuity complies with the requirements;

Principal	£330·250
Interest at the rate of 15 per cent. on £330·250 equals £49·537, and £49·537 per annum for 10 years at 3 per cent. amounts to	567·892
The amount of the principal at the end of deferred period is therefore	£898·142
When the term of revenue commences:	
Interest at the rate of 15 per cent. must be provided on the outlay	£49·537
Interest at the rate of 3 per cent. on the amount of £567·892 to which the interest has accumulated	17·037
Redemption fund to produce £330·25 in 20 years at 3 per cent. ...	12·291
And there remains, to produce the £567·892 of interest accumulated during the deferred period	21·135
The total revenue being	£100·000

The sum of £21·135 per annum invested at 3 per cent. for twenty years amounts to £567·897: which practically agrees with the £567·892 required.

Prof. Henry Louis said that he thought that the views of the writer in regard to discounting deferred values were illogical. Mr. O'Donahue appeared to be of opinion that money invested to return interest a few years hence should receive what they might call a "risky rate" on the capital only, and the ordinary rate upon the interest. This would be perfectly sound, provided that one received the interest; but, when the principle was applied to a coal-mining proposition, it would be found that it did not apply at all, because the risk of not receiving the interest (or what was looked upon as ranking as such) was, at least, as great as that of losing the capital. He differed on this point from Mr. O'Donahue, as it seemed to him that the risk was fully as great during the preparatory period of sinking as during the period of working, and, therefore, anyone who invested his money before that time was entitled to the high rate of interest.

Mr. T. E. Forster said that there seemed to be as many opinions and as many theories on this subject as there were stars

in the sky, but the only principle that would pass the authorities of Somerset House, was the principle laid down by Mr. George King.*

Mr. T. A. O'Donahue, replying to the discussion, wrote that he quite agreed with Prof. H. Louis that the risk is as great during the deferred period as during the period fixed for revenue, and his rule is based on that assumption: the rate of remuneration allowed during the deferred period being identical with that of the annuity-term: and his argument is that it should not be greater. Prof. H. Louis stated that the method "would be perfectly sound, provided that one received the interest." Were the revenue assured, there would be no justification for a high remunerative rate of interest; and therefore the principle could not be sound with such a condition. Mr. T. E. Forster should not be taken seriously in his reference to the stars—the fingers of one hand would have afforded a better simile. So far as he was aware, there were not more than three theories on the subject which could be put forward with any reason; and he did not know of any that had been published except the two dealt with in his paper. The Somerset House test is certainly a criterion of the practical utility of the rule, though it is not necessarily a convincing one of its logical accuracy. He had, however, good reason to believe that the principle laid down was acceptable to the officials of the Estate Duty Office; but, to make the matter more certain, he submitted his views to the Secretary. A reply was received, stating that he correctly gave the objections which the Estate Duty Office raised to certain tables for the values of deferred temporary annuities at two rates of interest. The reference to his rule was as follows, "that the formula† given on the sheet enclosed in your letter embodies the principle for which this Office contends."

References have been made to Mr. George King's admirable treatise on *The Theory of Finance*. In the third edition‡ of that book, a problem on deferred annuities at two rates of interest was stated, and conditions were defined; and this was followed by a rule complying with the conditions premised. His (Mr. O'Donahue's) rule, though deduced somewhat differently, yielded

* *The Theory of Finance*, by Mr. George King, first edition, 1882; second edition, 1891; and third edition, 1898.

† Equation 10, page 416. ‡ Page 38.

identical results with that given by Mr. King. He had, however, retained the elementary values for the factors, so as to enable the mining engineer to apply the rule more easily. He desired to make it clear, although Mr. King had deduced a rule to comply with certain conditions, that he was not disposed to say that the particular conditions premised were alone permissible; in fact, Mr. King stated that he had but little experience of the problem, as it was outside his own special sphere, and was of the opinion that the conditions should be decided by mining experts. On the other hand, he (Mr. O'Donahue) contended that the principle laid down was the correct one from which to obtain equitable results, and the Somerset House authorities apparently held the same view.

Mr. Edwin Kenyon delivered a lecture on the "Transmission of Power by Ropes."

The President (Mr. J. H. Merivale) moved a vote of thanks to Mr. Kenyon for his useful lecture.

The motion was cordially approved.

THE NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

EXCURSION MEETING,

Held at Axwell Park Colliery, Swalwell, December 5th, 1906.

ELECTRIC PLANT, AXWELL PARK COLLIERY.

The machinery throughout Axwell Park colliery is worked by electric power, comprizing hauling, pumping, ventilating, winding, screening, disintegrating, elevating, etc.

The winder is employed especially for the raising and lowering of workmen at a shaft near the face of the workings, as the bulk of the coal is conveyed by rope-haulage through a drift some distance away. It comprizes an Ilgner motor-generator set, consisting of a three-phase motor of 33 horsepower at 550 volts, a variable-voltage generator of 23 kilowatts, an exciter of 2 kilowatts, and a flywheel, weighing about 25 cwts. These are all supported on one foundation-bed, connected by rigid and flexible couplings, and they run at 1,200 revolutions per minute. The bearings are arranged for oil-ring lubrication. The momentum of the flywheel would enable a complete wind to be made, after cutting off the supply of current to the motor. The winder works a single cage and a counterbalance weight. The mechanical portion of the plant is fixed vertically over the pit about 55 feet above ground-level, and comprizes a rope-drum, 5½ feet in diameter, and the necessary speed-reducing gear, driven by a motor of 30 horsepower. A brake-wheel is fitted on the second-motion shaft; the brake is of the post type, and operated by an electro-magnet. An emergency brake, of the post type, working on the drum-shaft, can be operated from the cage by means of a rope suspended in the pit, or by the motorman stationed in the controller-house at the surface, or by the governor-gear if the speed exceeds the normal maximum speed by, say, 20 per cent. It is also tripped by the cage in case of an overwind. The brakes are capable of supporting the loaded cage, even if the counterbalance-weight on the opposite rope were removed. The controller is

similar to those generally used with Ilgner winding plants, except that the magnetic brake is also controlled by the speed-regulating handle. It is, therefore, quite impossible for the motorman to apply the operating brake, except when the controller-handle is in the neutral position; and, for the same reason, it is also impossible to start the winder before the operating brake is off. The speed can be controlled within $2\frac{1}{2}$ per cent. of the maximum. By a suitable arrangement of cams fixed to the depth-indicator, the speed of the cage may be automatically reduced, and gradually brought to rest at the end of a wind, and thus prevent overwinding. Cams are also fitted to regulate the rate of acceleration at the commencement of each wind. It is further intended to fix a second controller inside the cage, so that the attendance of onsetters and banksmen will be unnecessary during the night shift. For this purpose, it is proposed to use a flexible cable suspended beneath the cage. By means of an automatic slip-regulator connected to the rotor circuit of the three-phase motor, the speed of the motor, and, consequently, of the flywheel, may be controlled within certain limits. Energy in excess of 33 horse-power is obtained from the flywheel, and it is again stored during the intervals between the winds. The maximum speed of winding is 8 feet per second; the depth of the shaft, 255 feet; the period of a wind, 40 seconds; and the interval, 15 seconds.

The car for loading the coke-ovens has a carrying capacity of 4 tons, it is equipped with a series-wound motor of 10 horse-power and a British-Thomson-Houston controller. The current is obtained from a trolley-wire suspended along the centre of each track. The car automatically opens and closes the hopper-slides when loading, and the car-driver can work the bottom-slides of the car by means of levers fixed to the footplate, and thus discharge the coal into the coke-ovens without leaving his position on the car.

The electric current is generated at the Blaydon station of the Priestman Power Company, from the waste heat of Otto-Hilgenstock coke-ovens installed at Blaydon Burn colliery. It is supplied to Axwell Park colliery in conjunction with the County of Durham Electric Power Distribution Company, Limited, at a pressure of 5,500 volts on the three-phase system, and it is transformed to a pressure of 550 volts for use at the colliery.

THE NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

GENERAL MEETING,
HELD IN THE WOOD MEMORIAL HALL, NEWCASTLE-UPON-TYNE,
DECEMBER 8TH, 1906.

MR. J. H. MERIVALE, PRESIDENT, IN THE CHAIR.

The SECRETARY read the minutes of the last General Meeting, and reported the proceedings of the Council at their meetings on November 24th and that day.

The following gentlemen were elected, having been previously nominated:—

MEMBERS—

Mr. WALTER ROBERT ABEL, Mechanical Engineer, 8, Queen's Gardens, Benton, Newcastle-upon-Tyne.

Mr. EVAN COCKBURN, Colliery Manager, Waldridge Colliery, Chester-le-Street.

Mr. JOHN ALLAN CUNNINGHAM, Inspector of Boilers, P.O. Box 59, Dundee, Natal, South Africa.

Mr. GEORGE DIXON, Colliery Manager, c/o Messrs. Bird and Company, 100 and 101, Clive Street, Calcutta, India.

Mr. CLEMENT JONES, Colliery Manager, Neath Colliery, Cessnock, New South Wales, Australia.

Mr. GEORGE HENRY HALL SCOTT, Mining Engineer, 3, Eldon Square, Newcastle-upon-Tyne.

ASSOCIATE MEMBERS—

Mr. WILLIAM EASTWOOD, 93, Scar Lane, Milnsbridge, Huddersfield.

Mr. JAMES PARMLEY GRAHAM, 26, Cloth Market, Newcastle-upon-Tyne.

Mr. ROBERT NORMAN REDMAYNE, Woodside, Low Fell, Gateshead-upon-Tyne.

ASSOCIATES—

Mr. TOM STEWARTSON COCKBAIN, Under-manager, Usworth Colliery, Washington Station, S.O., County Durham.

Mr. THOMAS CRAWFORD, Surveyor, The Croft, Wrekenton, Gateshead-upon-Tyne.

Mr. John George Guy, Under-manager, Manor House, Wardley Colliery, Newcastle-upon-Tyne.

Mr. Andrew Pattison, Back-overman, Clara Vale Colliery, Ryton, S.O., County Durham.

Mr. Henry Richardson, Master-shifter, Clara Vale Colliery, Ryton, S.O., County Durham.

Mr. William Ridley, Jun., Surveyor, Mary Pit, Blaydon-upon-Tyne, S.O., County Durham.

Students—

Mr. Andrew D. Brydon, Mining Student, Millburn, Darlington.

Mr. Archibald Felce Dick-Cleland, Mining Student, 9, Cross Street, Camborne.

Mr. John Alfred Lister, Mining Student, 18, Baff Street, Spennymoor.

Mr. Thomas John Muse, Jun., Mining Student, Cornsay Colliery, Durham.

Mr. Robert Powley Wild, Mining Student, 9, Cross Street, Camborne.

DISCUSSION OF DR. J. A. SMYTHE'S PAPER ON "DEPOSITS IN A PIT-FALL AT TANFIELD LEA, TANTOBIE, COUNTY DURHAM."*

Dr. J. A. Smythe submitted samples of the deposit, a black gelatinous substance or "black stuff," found under an old peat-bed in a pit-fall at Tantobie. It was distinguished by a concentric arrangement of layers and conchoidal fracture, and evidently corresponded to the *saprokoll* of Prof. H. Potonié. From its occurrence only beneath the peat-bed, it was evidently derived from the peat, a view which was strengthened by its similarity in composition: and the higher nitrogen-content was also in harmony. Examination of the black stuff, by chemical means, shewed that it had affinities to the carbohydrates (that is, the group containing sugar, starch and cellulose) and to coal. The analogy to the carbohydrates came out in the analyses, which shewed a low percentage of carbon and a high percentage of hydrogen, oxygen and volatile matter. The analogy to coal was shewn by the similar behaviour which both exhibited towards the solvent pyridine. This extracted from both humus-like acidic bodies, rich in volatile matter, and the residues after extraction had very poor coking properties. Thus the black stuff occupied a position in some respects midway between the carbohydrates and the ligno-celluloses, and might be regarded

* *Trans. Inst. M. E.*, 1906, vol. xxxii., page 24.

as a transition-product between the cellulose of plants and some of the more important constituents of coal. According to Prof. H. Potonié's theory, it represented the raw material from which cannel-coal was made.

Prof. Henry Louis said that he had been very much interested in Dr. Smythe's work, which demonstrated a possible mode of origin of coal. The experiments of Dr. Martin Ekenberg, Stockholm, less known in this country than they deserved to be, shewed that it was possible to convert peat into a substance practically indistinguishable from ordinary coal, by the action of superheated steam at high pressures. Those experiments, taken in conjunction with Dr. Smythe's communication, seemed to offer some clue to the processes which converted woody and peaty matter into coal.

Prof. P. P. Bedson congratulated Dr. Smythe on what must be considered as a very valuable and interesting contribution to the subject of the conversion of woody matter into coal.

The President (Mr. J. H. Merivale) said that Dr. Smythe appeared to have supplied the missing link between vegetation and coal.

DISCUSSION OF MR. W. MAURICE'S PAPER ON "A RATEAU EXHAUST-STEAM-DRIVEN THREE-PHASE HAULAGE PLANT."*

Mr. W. C. Mountain believed that there was an important future for the Rateau turbine, in connection with the utilization of the exhaust-steam from winding-engines. It was stated that one kilowatt could be produced for every 38 pounds of steam at atmospheric pressure, exhausted to a vacuum of 26 inches from a winding-engine; and, consequently, if the winding-engine used more than 38 pounds of steam per horsepower, more power would be developed by the exhaust-steam than by the engine. In a plant of this description near Doncaster, it was hoped that 1,000 kilowatts would be produced from the exhaust-steam of two winding-engines, an additional amount of power from the

* *Trans. Inst. M. E.*, 1906, vol. xxxii., page 118.

exhaust-steam that would otherwise have been wasted. He understood that the plant at Hucknall colliery, described by Mr. Maurice, was giving very economical results.

The PRESIDENT (Mr. J. H. Merivale) remarked that the arrangement seemed to be taking away the character of the old winding-engine, in regard to which they had hitherto prided themselves that it was the most wasteful of steam of any kind of engine.

Prof. P. PHILLIPS BEDSON and Mr. HENRY WIDDAS' paper on "Experiments illustrative of the Inflammability of Mixtures of Coal-dust and Air" was read as follows:—

EXPERIMENTS ILLUSTRATIVE OF THE INFLAMMABILITY OF MIXTURES OF COAL-DUST AND AIR.

By P. PHILLIPS BEDSON, D.Sc., and HENRY WIDDAS, B.Sc.

Some years ago, Dr. Rud. Holtzwart and Dr. Ernst von Meyer described* an apparatus for and a method of testing the inflammability of mixtures of coal-dust and air. Briefly, the apparatus consisted of an arrangement whereby the dust was projected by a blast of air through a gap between two platinum-wires, and thus subjected to a series of electric sparks.

Experimenting in the manner described by Messrs. Holtzwart and von Meyer, and convinced of the utility of this method of examining the question of the inflammability of mixtures of coal-dust and air, the authors have extended and modified the apparatus in such a way as to enable them to study the question on a somewhat larger scale, and at the same time to gain, if possible, information which may prove serviceable in investigating the question of explosions in which coal-dust and other inflammable dusts play a part.

The apparatus consists of a bottle, *a*, about 116 cubic inches in capacity, closed by a stopper, in which are three glass-tubes, one, *b*, connected with a foot-bellows, a second, *c*, connected with a U-tube, *d*, containing mercury and serving as a manometer, whilst the third tube, *e*, is attached by indiarubber-tubing to the explosion-apparatus. The explosion-apparatus consists of a glass-tube, *m*, $1\frac{1}{2}$ inches in diameter, attached to a cubical tin-box, *f*, 4 inches long, provided with mica-windows, *g*, at the back and front, circular openings above, *h*, and below, *i*, and, on either side, cylindrical collars, *j* and *k*, serve as a means of attaching the glass-tubes, *l* and *m*, $1\frac{1}{2}$ inches in diameter. Through the circular opening at the bottom, *i*, the gas-jet, *q*, used to inflame the dust is introduced; or the inflammation may be effected by an electrically-heated coil of platinum-wire, suspended between copper-wires, introduced through *h*.

* "Ueber die Ursachen von Explosionen in Braunkohlen-briquettefabriken (The Causes of Explosions in Brown-coal Briquette Works)," *Dingler's Polytechnisches Journal*, 1891, vol. cclxxx., pages 185 to 190 and 237 to 240.

The method of working is as follows:—A weighed quantity of dust is brought into the wide tube, *m*, on the left side of the box, and the tube is closed by a cork, *s*, carrying the glass-tube, *n*, connected with the compressed-air supply. The air in the bottle is compressed to the desired amount by the foot-bellows, the gas-jet, *q*, having been brought into position in the box, the tap, *p*, is quickly opened, and, by the blast of air, the dust is blown into the flame, *q*, and the behaviour of the dust carefully noted.

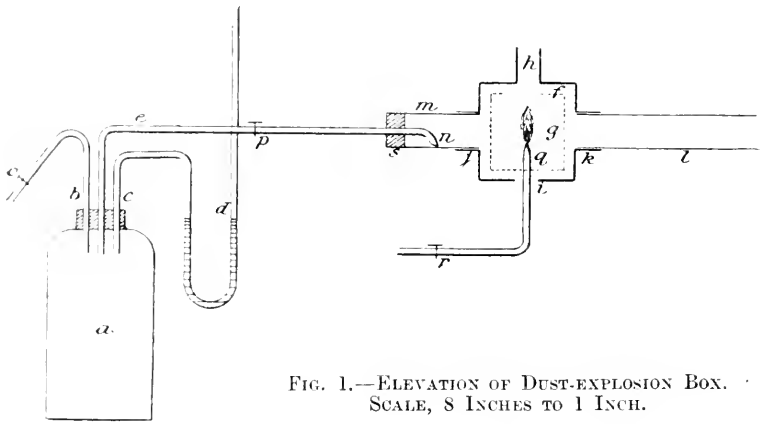


FIG. 1.—ELEVATION OF DUST-EXPLOSION BOX. SCALE, 8 INCHES TO 1 INCH.

The first series of experiments shown comprized the ignition of mixtures of finely-ground brown-coal and air by (*a*) electric sparks, (*b*) a platinum-wire heated electrically, and (*c*) a small gas-flame. In the second series of experiments, the behaviour of finely-ground dust of each of the following materials was shown, a small gas-flame being used for the ignition:—(*a*) Brown coal, (*b*) bituminous coal, (*c*) dant, (*d*) charcoal, (*e*) wheat flour, (*f*) wood saw-dust, (*g*) lycopodium, (*h*) metallic aluminium, and (*i*) metallic magnesium. In each case, 15·43 grains or 1 gramme of material was used; and in every instance, save that of dant and of charcoal, inflammation of the cloud of dust took place, developing varying degrees of explosive energy. The dant and the charcoal alone did not fire. This behaviour of dant and charcoal had a special interest, in view of the important part that dant was, according to some authorities, assumed to play in coal-dust explosions.

An experiment was also shown in which the flame produced by the ignition of dust at one point was made to ignite a cloud of dust at a point some 2 or 3 feet distant from the point of

inflammation. The different stages of the burning of a mixture of ordinary coal-gas and air, developing into explosive combustion, was illustrated by an experiment.

Experiments were also shown in which the fact that mixtures of air and dust of combustible materials comported themselves like mixtures of air and a combustible gas was illustrated. In these experiments an apparatus represented in Fig. 2 was used. It consists of a glass-tube, *a*, $1\frac{1}{2}$ inches in diameter and 3 inches long, closed at the lower end by a cork, *b*, through which passed a funnel-shaped glass-tube, *c*, connected with a foot-bellows; the wide end of *c* was covered with cotton-gauze, *d*. The upper end of *a* was covered by cotton-gauze, *e*, kept in position by a metal collar, *f*. On the cotton-gauze, *e*, a quantity of coal-dust, *g*, was placed, and into the collar, a tube, *h*, some 8 or 12 inches long was fitted. The whole apparatus was held in a vertical position.

FIG. 2.—ELEVATION OF DUST-EXPLOSION TUBE. SCALE, 4 INCHES TO 1 INCH.

By means of a blast of air from the foot-bellows, a cloud of dust was produced in the vertical tube, *h*, and ignited by a flame brought to the mouth, *i*, of the tube. When the dust was burning at the open end, *i*, the air-current was slackened and the flame was seen to travel down the tube, *h*, igniting the explosive mixture of air and dust in the lower part of the tube. The combustible dusts used in these experiments were coal-dust, finely divided aluminium and lycopodium.

Prof. P. P. BEDSON gave a demonstration with the apparatus described in the paper, prefacing the demonstration with the statement that he had the benefit of the collaboration of Mr. Henry Widdas in this investigation, since Mr. Widdas, as the holder of the Scholarship of the Institution of Mining and Metallurgy given annually to Armstrong College, was enabled to extend his years of study and devote himself to research.

Mr. W. C. BLACKETT asked what result might be expected if the tubes were prolonged so as to have greater resistance, so to speak, in front of the explosion. Would it be expected to develop

a greater pressure of the atmosphere and a corresponding increase in the violence of the explosion? In other words, would the air, if it was at greater pressure, develop a higher explosive effect?

Mr. F. Coulson asked what would be the effect of a continuous supply of coal-dust throughout the full length of the tube, and whether such a continuous supply of dust, if disturbed, would increase the severity of the explosion.

Mr. T. E. Forster asked whether Prof. Bedson proposed to make any experiments, so as to shew what amount of moisture should be present to make the dust non-explosive.

Mr. M. Ford asked what was the condition of the dust, in regard to fineness, that had been used in the experiments.

Mr. P. Kirkup asked, supposing that the tube were considerably lengthened, and had a layer of dust distributed along its entire surface, whether the explosion would extend over the whole distance. He also asked, as regarded the coal-dust which had been used, whether this dust was actually obtained in the mine, and, if so, whether it was obtained from a haulage-way, or return-airway, at the working-face, or elsewhere.

Mr. W. C. Mountain asked whether the coal-dust used in the experiments was actual dust as found in the pit, or whether it had been specially ground for the purpose of the experiments.

Mr. W. Cochran Carr asked whether dant mixed with coal-dust would have any effect on the explosion, as dant itself did not seem to give much violence. Would a small proportion of dant minimize the effect of a coal-dust explosion?

Prof. P. P. Bedson, replying to the discussion, said that the dusts, used in the experiments that day, were artificially produced. The dust from the coal had been prepared by grinding and sifting through a sieve having 100 meshes to the lineal inch. Experiments had been made with some natural dusts, and these, although giving an explosion, did not ignite so readily as freshly ground coal: in fact, there was a marked difference between coal freshly ground and that which had been kept for some days. For instance, screened dust was not so sensitive as dust freshly made from solid coal. Experiments had not been

made as to the influence of dant, but he imagined that dant would have a deadening influence. With regard to the effect of prolonging the tubes, the experiments which had been made were not suitable for deciding the point; they required an explosion in a closed chamber.

As to the continuous supply, it would depend on the manner in which the coal-dust was supplied. If the coal-dust was lying on the bottom of the tube, they could fire along the tube without disturbing the dust, but if the dust was disturbed, and was raised in a cloud, firing at the end of the tube would have a very marked effect. In the case of dust lying on the bottom of the tube, the flame would pass over it: but, if it formed a cloud, and was in motion, it was much more readily inflammable. He hoped, at some future time, to be able to communicate the results of experiments dealing with the influence of moisture.

The President (Mr. J. H. Merivale), in moving a vote of thanks to Prof. Bedson and Mr. Widdas for the demonstrations, said that coal-dust was becoming a classic question in connection with Armstrong College, for Prof. Freire Marreco directed his attention to it upwards of 30 years ago, and Prof. Bedson took up the question on the occasion of the explosion of an air-receiver at Ryhope Colliery some 23 years ago. The members were exceedingly indebted to him and his coadjutors, and hoped that they would continue to give them the benefit of their researches for many years to come.

The vote of thanks was heartily adopted.

Mr. Otto Simonis read the following paper on "Liquid Air and its Use in Rescue-apparatus":—

LIQUID AIR AND ITS USE IN RESCUE-APPARATUS.

By OTTO SIMONIS.

Some years ago, the writer had the pleasure of exhibiting to the members a mining rescue-apparatus, fed by compressed oxygen, and it represented one of the first self-feeding rescue-helmets constructed. Since that time, science and practice have continually worked to improve upon this class of life-saving apparatus.

The so-called regenerating appliances, which strove to overcome the short period of the supply of self-feeders by regenerating processes, have, after the efforts of Mr. G. A. Meyer, of Herne, Westphalia, and Mr. E. Giersberg, of Berlin, been brought to the utmost perfection by the Berlin Oxygen Company, and especially after a separation in this firm by the Drägerwerk, of Lübeck. These appliances had, however, the great disadvantages of great weight, high temperature in the helmet, and heating of the air regenerated by a chemical process; in addition, there was the danger, always present, of some of the particles of the absorbent being carried into the lungs and producing serious internal injuries; and, above all, the mechanism was exceedingly complicated. The Vienna type of pneumatophore, which creates the oxygen as required, by a chemical process continuing under work, has succeeded in reducing the weight, but it could not overcome the other disadvantages mentioned. American patterns have never advanced beyond the firstnamed type without regeneration, and have never succeeded in supplying more than heavy and short-living self-feeders, although their simplicity leaves nothing to be desired.

These considerations led the writer, for a long time, to endeavour to discover an altogether new principle, and he has now perfected the "Aerolith," a liquid-air rescue-apparatus, which he has now the pleasure of bringing before the members.

The entire apparatus, weighing about 14 pounds, is easily carried on the back without any encumbrance, and it gives an absolutely pure and deliciously cool air-supply for up to 3 hours' working. It does not contain any chemicals; it is without any complications whatsoever; there is not a single valve in the whole apparatus; and its use does not require any special training.

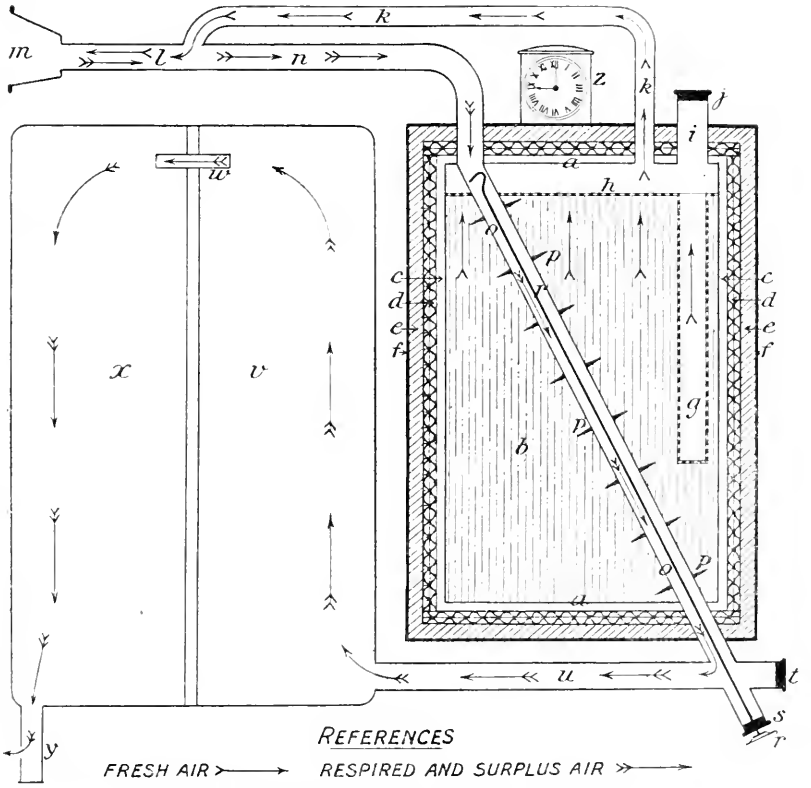


FIG. 1.—DIAGRAM OF THE AEROLITH LIQUID-AIR RESCUE-APPARATUS. SCALE, 6 INCHES TO 1 INCH.

Atmospheric air liquefies at a temperature of −191° Cent., and is compressed to about the seven-hundredth to eight-hundredth part of its original volume. Consequently 1 gallon of liquid air will evaporate into 700 to 800 gallons (110 to 130 cubic feet) of atmospheric air.

This principle has been applied in the following manner:— A solid-nickel receptacle, *a*, packed with asbestos-wool, *b*, in-

sulated against outside and atmospheric influences by a vacuum-space, *c*, an air-space, *d*, a layer of felt, *e*, and a leather cover, *f*, measuring about 16 inches long, 11 inches wide and 4 inches thick, is carried on the back like a knapsack (Fig. 1). The nickel vessel, *a*, has an inlet, *i*, for the liquid air, provided with a screw-cap, *j*. The outlet for the vaporized air is connected by a flexible-metal tube, *k*, to the combined pipe, *l*, leading to the fireman's face-mask or miner's mouth-piece, *m*. The vessel, *a*, is traversed in a diagonal direction by a tube, *o*, fitted with radiators, *p*, connected at the upper end by a flexible well-insulated metal-tube, *n*, to the combined pipe, *l*, and at the lower end by the tube, *u*, to a double air-bag, *r* and *x*, which is fitted on the back of the vessel, *a*, and attached to the leather cover, *f*. The exhaled air passing through the diagonal tube, fitted with radiators, gives all its heat to the liquid air and evaporates it. The diagonal tube is fitted with a cleaner, *r*, and openings, *s* and *t*, are provided so as to give access for cleaning purposes. A perforated cylinder, *g*, and a perforated plate, *h*, are fitted for the quick distribution of the liquid air poured into the vessel, *a*. The remainder of the vessel is filled with asbestos-wool capable of absorbing 1 gallon of liquid air. The double bag, *r* and *x*, made of material used for divers' dresses, has an opening, *w*, in the separating sheet and an outlet,

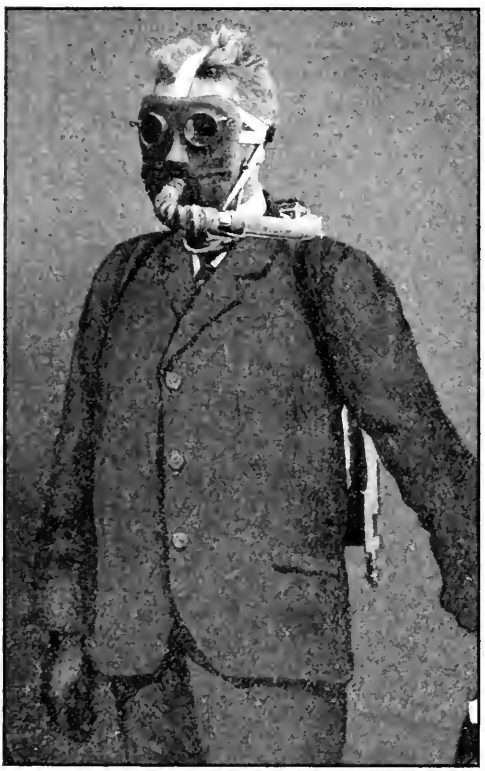


FIG. 2.—AEROLITH LIQUID-AIR RESCUE-APPARATUS.

y, at the bottom of the second bag, for the issue of the exhaled air, mixed with any superfluous fresh evaporated air at over-pressure. The combined pipe, *l*, consists of strong braided india-rubber tubing, to which a fireman's face-mask, *m*, covering the mouth, nose and eyes, or a miner's mouthpiece, with nose-pinchers, etc., may be screwed on at will. The alarm-clock, *z*, is provided so as to give timely warning that the supply of liquid air is nearing the end.

When carried on the back, in actual work, the apparatus, when fully charged weighing under 25 pounds, affords full use of both arms, and is no encumbrance whatsoever (Figs. 2 and 3).

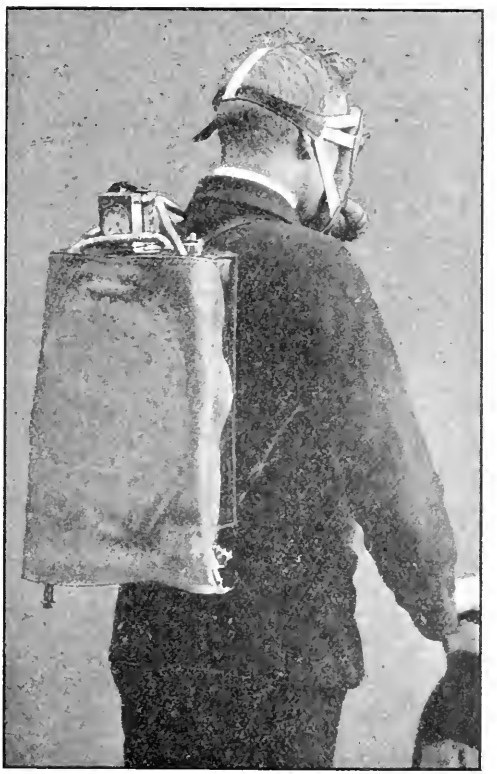


Fig. 3.—Aerolith Liquid-air Rescue-apparatus.

When the desired quantity of liquid air has been poured into the nickel vessel (1 quart giving at least $\frac{3}{4}$ hour's work), 1 gallon equal to 3 hours' work being the maximum capacity of the vessel, pure and deliciously cool air will evaporate and flow to the face-mask. The harder the person works, the more hot air will be exhaled into the diagonal radiator-pipe, and the more fresh air will be vaporised by the increased amount of heat. Consequently, the air-supply is automatically regulated, and increases with the requirements of the wearer. Any surplus vaporised air, which may not be used, will pass downward with the exhaled

air, purifying it at the same time, and will be stored in and distend the double bag, at the back of the apparatus, and will, as soon as the pressure becomes excessive, escape into the open air. The fresh air-supply is ample under all requirements, and the air in the double-bag can always be utilized as a breathable reserve-supply.

The fresh air-supply is absolutely pure, as the always high percentage of oxygen increases with the time that the apparatus is in use. The liquid air contains about 2 parts of oxygen to 1 part of nitrogen. The nitrogen evaporates more quickly than the oxygen, and, consequently, the wearer works under the best possible conditions.

Liquid air can be stored in the vacuum-vessels designed by Sir James Dewar, and will then lose, under ordinary atmospheric conditions, not more than 5 to 10 per cent. by evaporation per day. It can, even at the present moment, where no purely commercial use for liquid air has been universally adopted, be purchased for 5s. per gallon: whereas it can be produced by small plants at 1s. per gallon, and by large plants at 6d., 3d., or even less per gallon. Liquid air can be transported with absolute safety by rail or car. For central rescue-stations or large coal-mines, however, it would certainly be desirable to erect an air-liquefying plant. A plant, requiring about 8 horsepower, producing about 1 gallon of liquid air per hour, and not occupying more than about 45 square feet, can be bought for about £400.

The writer would have liked to enter more fully into the uses of liquid air generally, and the scientific results of his liquid-air rescue-apparatus, but the purpose of this demonstration is only to bring this new invention and its fundamental points to the knowledge of the members, and he sincerely trusts that in so doing, he has secured their interest and support.

One of the appliances has been purchased by the Royal Commission on Accidents in Mines, for detailed experiments and research; and a large liquid-air plant has been erected at Baron Rothschild's coal-mines in Austria, the Aerolith apparatus being substituted for all the latest types of mining rescue-appliances heretofore used, and, good as these may be, they are now giving way to the common foe of all good things, "the better."

Mr. R. Cremer (Leeds) wrote that as the evaporation of the liquid air, absorbed by the asbestos-wool packing in the aerolith, was caused by the heat from the exhaled air, such evaporation would most likely be not very uniform. Partly water-vapour and carbon dioxide would freeze upon the inner side of the diagonal tube, reducing the sectional area of this tube and possibly blocked this entirely, lessening in any case the uniform exchange of heat, so that less and less air would evaporate from the receptacle during the lengthened use of the apparatus. The produced fresh air (110 to 130 cubic feet per 3 hours, or 0·61 to 0·72 cubic foot per minute) appeared too small, as more than 1·60 cubic feet per minute were needed when the wearer had to carry out heavy work. Therefore a considerable amount of exhaled air would have to be re-inhaled without the carbon dioxide being perfectly eliminated during the short time allowed for cooling between two respirations. A further serious drawback of the aerolith apparatus in practical use was undoubtedly the non-existence of any appliance by which the wearer was warned that the supply of liquid air was nearing exhaustion. After the latter had been evaporated, the frozen carbon dioxide in the exhaling tube would evaporate, and this gas would then be inhaled. For the practical use of apparatus, like that described by Mr. Simonis, a constant large storage of liquid air was absolutely necessary. This stock could not be kept in small Dewar vessels, but would have to be kept in sheet-iron vessels, containing about 11 gallons, fitted with an isolating wool-mantle. The loss, by evaporation, of liquid air in such vessels, containing 11 gallons, amounted to about $\frac{1}{2}$ gallon per hour. The air-liquefying machine, therefore, must be able to supply this loss, and, when the apparatus was in use, it must produce the consumed air, that was $\frac{1}{3}$ gallon per hour. Therefore, the machine would have to produce at least $(\frac{1}{2}+\frac{1}{3}=)$ $\frac{5}{6}$ gallon of liquid air per hour. Further, as liquid air had the property of generating nitrogen only at the beginning of its evaporation, still more air had to be liquefied in order to keep $\frac{5}{6}$ gallon of usable liquid air in stock. The cost of air-liquefying, therefore, amounted, for one rescue-apparatus kept ready for use, to at least $\frac{5}{6}$ gallon or 3d. per hour, or to 2s. 6d. per day of 10 working hours. Ten rescue-appliances would require a liquefying machine with a capacity per hour of about $[\frac{1}{2}+(\frac{1}{3}\times 10)=]$ 4 gallons; and the cost would be (4 gallons at

3d. or) 1s. per hour, or 10s. per day. The cost of a Linde air-liquefying machine, with a capacity of 20 litres or 4·4 gallons per hour, was £1,500. These machines were easily thrown out of order, and it was very probable that a second machine, to be used as a reserve, would be necessary. The wear-and-tear of these machines was considerable, and the annual depreciation should, therefore, be reckoned at 15 to 20 per cent. of the cost-price, that was, for the abovementioned machine, £225 to £300 per year.

He was afraid, owing to the continuous evaporation of the oxygen and the nitrogen from the liquid air in the receptacle, that a concentration of the heavy gases (argon, krypton, xenon, etc.) would occur, and after about one year, the receptacle would not contain 11 gallons of liquid air but almost the same quantity of liquid argon, etc., unfit for breathing; and consequently, the whole amount stored would have to be replaced.

Mr. W. Morton Jackson (Manchester) wrote that liquid air was produced at the works of the British Oxygen Company, Limited, and though he was quite ready to admit that it possessed many characteristics which indicated its peculiar suitability for use in rescue-apparatus, he was of opinion that (1) its extreme volatility at ordinary temperatures and (2) the fact that the oxygen and nitrogen did not evaporate from it in constant proportions, must render its proper control in such apparatus a very difficult matter. He might mention that the Dewar vacuum-vessels were made of glass, and he did not know of any metallic vessel that could approach them for storage purposes. He would like to test the efficiency of the solid nickel-flask used for the storage of liquid air in the aerolith apparatus. The cost of the production of liquid air was also much higher than estimated by Mr. Simonis.

Mr. M. H. Habershon (Sheffield) wrote that, without more information than that contained in the paper, it was difficult to form any opinion as to the probable value of liquid air for use in connection with rescue-apparatus. He thought that Mr. Simonis was misinformed as to oxygen-appliances, when he referred to the disadvantages of high temperature and the danger of particles of the absorbent being carried into the lungs, neither of which was present with the latest types. The Draeger apparatus had been worn, and work done for 2½ hours without any inconvenience

whatever from heat, and there was absolutely no liability of any particles getting into the breathing-tubes. With this apparatus, it was possible to climb over falls, move heavy stones, and crawl through low and narrow places without any distress. With the Vienna type of pneumatogen, however, the heat caused by the chemical action had hitherto been found an inconvenience; but he was informed that a new type was being introduced, which did not possess this fault. He thought that the loss of 5 to 10 per cent. of liquid air per day from evaporation might be some detriment to its employment in rescue-apparatus, and it was possible that the most likely application would be as an auxiliary to some oxygen apparatus; but, until some commercial use was found for liquid air, he was afraid that it would not be likely to supersede oxygen. He asked Mr. Simonis to explain more clearly how the expired air was voided from the apparatus.

Mr. Joseph Dickinson (Pendleton, Manchester) wrote that he had seen previous inventions for the same purpose and witnessed tests, in poisonous gases and under water, intended to show the use of such apparatus for re-entering mines with the ventilation destroyed by explosion or fire; and he had assisted in the mine where bags, containing chemical preparations, were breathed through, but he could not say that on any occasion had he known life to be saved by the use of any such invention. In most of the rescue-operations, the party is composed of true heroes: other persons with distaste for such work, or having important letters to write, or being imperatively wanted elsewhere, being excused. There is risk to those who take part in the work, and in it delay occasionally occurs by an explorer being knocked down, or his head cut by a fall of stone, requiring attention, or it may be his being sent out amid his requests that his name may not be mentioned lest it might alarm his wife or friends. On rare occasions, some delay also occurs by excessive zeal inducing venture into poisonous gas requiring attention; and exceptionally excessive staggering occurs that apparently might be restrained. When thus advancing, time is occupied in bratticing between distant cut-throughs to make up temporarily blown-out air-stoppings, which might be saved if some reliable portable breathing-apparatus were at hand. The use of such apparatus is also apparent when being lowered in a disarranged shaft, and for ex-

ploring in advance of the air-column. One hails, therefore, with satisfaction, the new aerolith with liquid air in a case, without chemicals, valves or complication, the whole weighing 25 pounds —that is, assuming the transition of air from the liquid to the gaseous state to be reliable. It should not be supposed, however, that former inventions for the same purpose are devoid of such usefulness. One great obstacle has been to trust to such apparatus amid such varied surroundings. Even the representing persons, after exhibiting joiner's work in poisonous gas, when protected by the apparatus, have declined the fine advertisement offered of entry into a pit, alleging the risk to be too great. Ordinary explorers may be reliable men, yet they might not think it prudent to isolate themselves among newly-loosened débris, the touch of which is critical, and with a bag on their back weighing 25 pounds, which might be destroyed. Besides this, let them imagine, after passing through irrespirable gas, them coming to a miner stronger than themselves shut in an unbreathable *cul-de-sac* or stocking-end. A drowning man loses consciousness. Those only who have realized how their arms have become pinned and their head submerged by the unconscious person (probably kind and good under ordinary circumstances) know fully what desperation may and does bring about. The rescuer might have to give up his apparatus. Hitherto, the safety-lamp has proved invaluable for testing at the front when re-entering. A reliable breathing-apparatus might assist: but taking in fresh air for all is requisite. Caution is therefore needed in making advances too far ahead through poisonous gases under such circumstances.

Mr. Hermann Grahn (Bochum, Germany) wrote that the remarks of Mr. Otto Simonis about liquid air and its use in rescue-apparatus were worthy of attention. It would, however, be too early to maintain at the present moment that the aerolith would replace other breathing-appliances, such as the Draeger, Shamrock or pneumatogen types, or even that it had replaced them. Up to the present time, the employment of the aerolith had not yet passed the first experimental stages. He would only commence experiments with it in the near future, and he would employ for that purpose an apparatus which had been invented by Mr. O. Suess, in Ostrau, Moravia, and manufactured by the Hanseatischen Apparatebau-gesellschaft. It did not appear that

any great risk was involved in the erection of an apparatus for the production of liquid air, because such a machine could be used at any time, not only for producing liquid air but also for the production of oxygen.

Captain J. A. Hamilton (Chief Officer of the London Fire Brigade) wrote that experiments had been carried out at headquarters with the following smoke-helmets:—Chapin-Sherman, Draeger, Fleuss-Siebe-Gorman, König, Vajen-Bader and Simonis liquid air. The difficulty in connection with the liquid-air helmet, however, was that if liquid air was not readily obtainable, a special plant had to be installed, which cost about £400. The liquid air evaporated at the rate of about 6 per cent. per day, and it was necessary to have very special containing vessels. The cost of maintenance was about 5s. per week for each helmet. He (Captain Hamilton) had not yet adopted any self-contained helmet in the London Fire Brigade, as the experiments were not completed. The pattern now used by the Brigade was the König helmet, but it was not a self-contained one.

Mr. Otto Simonis (London), replying to the discussion, wrote that he was well conversant with oxygen-appliances; he had himself worked in the Draeger apparatus for 1½ hours, not very long ago, and he was sure that anybody who had used the Draeger apparatus would certainly have been delighted, after about ½ hour's work, if he could have been supplied with air at a lower temperature. He certainly admitted that the Draeger apparatus was almost brought to perfection, so far as regeneration through caustic soda and other chemicals was concerned, but the very use of these was a danger. It might be interesting to Mr. Habershon to know that he (Mr. Simonis) had brought both the Draeger and the Giersberg apparatus to this country in 1903, and that he had despatched one of the first mine-equipments with Draeger apparatus to the colonies.

He certainly agreed with Mr. Joseph Dickinson, who dealt with the subject from a different point of view, that it required a hero at all times to go and do rescue-work. So far as he was personally concerned, he would have no hesitation whatever in going down into a pit with the apparatus to do such work, always provided that he was not going alone. He considered

that it was every man's duty to attempt the rescue of a fellow-creature, who might be in danger; but it was an absolutely undue risk to do so alone.

He was on the most friendly relations with Mr. O. Suess and the Hanseatischen Apparatebau-gesellschaft, and the aerolith apparatus was identical with theirs.

He was pleased to notice that Captain J. A. Hamilton, who was, at the present time, experimenting with a Simonis liquid-air helmet, confirmed the statement that the cost of maintenance was about 5s. per week. The König helmet, referred to by Captain Hamilton, was not a self-feeding helmet, but one to which the air was pumped through a tube.

The storage of liquid air in metal tubes, suggested as a necessity by Mr. Cremer, would be detrimental, and he would strongly advise Mr. Cremer not to remain in the neighbourhood of such a loaded tube, as within a very short time the explosive power of the liquid air would be developed, and the tube would explode with about three times the force of dynamite. There was no reason for not storing liquid air in Dewar vacuum-vessels of 0·44 gallon (2 litres) or 1·10 gallons (5 litres) capacity and certainly he was, as well as everybody else, handling this material very successfully. The percentage of argon, krypton, xenon, etc., in liquid air, referred to by Mr. Cremer, was so small that it was of no practical importance.

The produced quantity of fresh air of 130 cubic feet, or about 0·7 cubic foot per minute, was for all practical purposes an ample supply, and with the diagonal tube as an evaporation-controller (although such evaporation did not depend entirely on the same) a very satisfactory equality in the air-supply was obtained.

The following comparison shewed the costs of the Simonis, the Draeger and the pneumatogen systems:—(1) A liquid-air plant, with a capacity of 1·10 gallons (5 litres) per hour, was at present working at one of Baron de Rothschild's coal-mines, and produced liquid air at a cost of 1s. 2d. per gallon (3d. per litre); and a practice of 2 hours with the apparatus would cost under 1s. (2) A practice of 2 hours with the Draeger apparatus, requiring two cartridges at 3s. each and two oxygen-cylinder charges at, say, 2s. each, would cost 10s. (3) A practice of 2 hours with the pneumatogen, requiring three cartridges at 4s. each, would cost

12s. Therefore, for every practice of 2 hours, the Simonis apparatus was 9s. cheaper than the Draeger apparatus and 11s. less than the pneumatogen; but this saving was diminished by the loss through evaporation. In a rescue sub-station, requiring 4·4 gallons (20 litres) of liquid air always in store, the loss, when stored in Dewar bottles, would be at the rate of 5 per cent. per day, or 0·22 gallon (1 litre) or 3d. per day, or £4 11s. 3d. per annum. Therefore, this sub-station required, for replacement, 1·1 gallons (5 litres) of liquid air every fifth day. The standard number of practices in Austria and Germany was four times per week, and this necessitated, including evaporation, a supply of, say, 0·88 gallon (4 litres) per week-day. Consequently, a liquefying plant, with a capacity of 1·1 gallons (5 litres) per hour, working 60 hours weekly, would suffice to supply twelve rescue sub-stations; and it would cost, including the expense of erection, say, from £500 to £600.

Four practices per week, at twelve sub-stations, implied 2,500 practices per annum, and the saving of the Simonis against the Draeger appliance, at 9s. per practice, amounted to £1,125, and against the pneumatogen apparatus to £1,375. If, in this country, the number of practices were reduced to the absolute minimum of one per week at every sub-station, or 600 per annum, there would be a yearly over-production of about 1,760 gallons (8,000 litres) of liquid air from the plant for re-sale, and there would be a saving against the Draeger of £270, and against the pneumatogen of £330. From these savings the loss from evaporation of £4 11s. 3d. per sub-station, or, say, £55 must be deducted; and the net saving would be £215 or £275 respectively. The 1,760 gallons (8,000 litres) of over-produced liquid air might be sold to iron-works or blast-furnaces at, say, only 2s. 4d. per gallon, or a profit of 1s. 2d. per gallon (6d. per litre, or a profit of 3d. per litre), or £100 per annum. In addition, the liquid-air plant would, at the same time, have produced compressed oxygen, which was marketable everywhere nowadays. Consequently, at a central rescue-station in a mining district, with sub-stations at the various pits, a liquid-air rescue-installation would, through the profit on the surplus liquid air and through savings, as compared with other rescue-systems, even calculated under the most unfavourable assumption of only one practice per week, very nearly balance its own cost.

He thought that he had clearly shewn that the Simonis apparatus had not only far-reaching advantages for its wearer, but that it had also the great advantage of being more economical than any other system. As soon as the use of liquid air for commercial purposes had become more general, a central rescue-station, with spare plant, would be able to sell such quantities of liquid air as would give a satisfactory return on the cost of erection and maintenance of the plant for rescue-work.

Dr. J. Adamson (Hetton-le-Hole) wrote that Mr. Simonis' paper was very interesting, and, as the subject was comparatively new to him, he felt that he was not at present competent to make any remarks. He was strongly of opinion, however, that the members of the St. John Ambulance Brigade, trained as they were to act in unison and to obey at once any orders given, were eminently fitted to carry out the use of rescue-apparatus at mines.

Mr. Stuart C. Wardell (Alfreton) wrote that, in his opinion, a liquid-air rescue-appliance was not of much use except for exploring main roads that were free from falls and obstructions, and that it would not be of much help where roads were nearly closed with only room to crawl over. Members of the St. John Ambulance Brigade would be glad of any instruction that had for its object the saving of life, and they would gladly avail themselves of any training in the use of rescue-appliances, but to procure the apparatus necessary for this training would be somewhat difficult.

Mr. Henry Hall (H.M. Inspector of Mines) wrote that the use of rescue-apparatus required special training of the men and frequent practices; and the care of the helmets, etc., with their delicate valves, would have to be specially attended to, otherwise there would be great danger to those using them. He was of opinion that when the matter was taken in hand the difficulties would be found to be much greater than could possibly have been anticipated. A central station was being established in Lancashire as a beginning, and the managers of different mines might send men thither to be trained by experts. This might be developed into several branches later, but at the central station

it was hoped that they would always be able to call on a reliable body of men to send anywhere, as well as to test various appliances that might be invented.

Mr. R. Richardson (Barrow collieries) wrote that members of the St. John Ambulance Brigade, employed at individual collieries, could most suitably be trained in the use of rescue-appliances. These appliances must be available quickly in case of accident, and, consequently, must be worked by men employed at the colliery; further, there must be enough trained men at each colliery to relieve one another from time to time. A head official must not lead an exploring party, as his services would be required in other directions after a serious explosion. He did not think that rescue-appliances would enable those wearing them to perform quite what most people expected, as they were cumbersome things at best: and, after an explosion, in his experience, the roads which had to be travelled were usually in such a condition as not to admit of anything of a larger size than the body of a man to get through with safety. Rescue-appliances would be useful in conjunction with an ordinary exploring party, to go a little in advance and to repair stoppings temporarily, so as to restore the ventilation. They would also be useful in the case of a man being prostrated by dangerous gases in a place, and, if they could be got there quickly enough, no doubt he would be rescued; but, under ordinary conditions, in his opinion, too much was expected from their use.

In Yorkshire, there are central stations supported by three or four collieries, where, say, six men are sent at a time so that they may be thoroughly trained; and arrangements are being made so that, in addition to these men, each colliery will employ a man thoroughly acquainted with the appliances. These may then be kept at each colliery for use in case of accident, and this man would ensure that they were absolutely in perfect working order before any person was sent into the mine.

Mr. Arthur Ellis (Wigan) wrote that, in April last, a committee was appointed by the Lancashire and Cheshire Coal Association to consider the advisability of forming a rescue-brigade and station in connection with the association, and many meetings had been held since that date to discuss the question from all points of view. The members of the committee had

visited rescue-stations that had been already established at Tankersley and Normanton, and had an opportunity of seeing various forms of apparatus in use. It would appear that it was quite practicable to train miners in the use of the apparatus, although a considerable amount of training might be necessary, as the apparatus in the hands of an untrained man was worse than useless. The idea of the committee was that an experimental gallery should be built in connection with the central station, capable of being charged with a noxious atmosphere, and made to represent, as far as possible, the conditions that would be encountered in a travelling-road underground after an explosion. The workmen from the various collieries would attend the station periodically for courses of instruction, and, after they had become accustomed to wearing and carrying the apparatus, they were to be exercised in the experimental gallery in a noxious atmosphere for short periods. It was hoped in this way that a considerable number of men, from each of the collieries taking part in the scheme, would become accustomed to the use of the apparatus, and be able to work whilst wearing it. The class of men who were to be trained were ordinary colliers, but he believed that preference would be given to members of the different ambulance-classes, and it was not anticipated that there would be any difficulty in instructing intelligent men in the use of the apparatus. Although he (Mr. Ellis) had had no practical experience in the matter, he thought, from what he had heard, that there would be no difficulty in the way of training such men as belonged to the St. John Ambulance Brigade, in the use of the apparatus. It was intended that a certain number of men belonging to each colliery should be trained in the work, and it was anticipated that one or two sets of apparatus would be provided at each colliery. In the event, therefore, of an accident, or of an underground fire, the manager would be able to send down his own trained men, at once, to cope with the danger. In the event of his own men being insufficient in number to deal with the outbreak, men trained in the use of the apparatus could be drafted from the neighbouring collieries, and further sets of apparatus sent from the central station; but it was, of course, essential that, at any rate, some of the rescue-party should be men who knew the underground workings of the mine where the work was to be done.

In regard to the nature of the apparatus to be used, it was difficult to speak with any degree of confidence, as, apparently, there were several kinds of apparatus, none of which appeared to be absolutely perfect as yet. In one class of helmet, with a glass front, the wearer's mouth was free, and the wearer was able to speak and be heard to a certain extent: while, in another class, the mouth-piece was held in the mouth and the wearer could not speak. It had been suggested that a rescue-party should consist of four or five men, the leader of the party wearing a glass-faced smoke-helmet, and it would be his duty to give directions and instructions while the work was in progress: while the other members of the party, who were to be the workers, would wear the other class of apparatus.

Mr. Claude B. Palmer (Pelaw-on-Tyne) wrote that the training of workmen at collieries to assist in rescue-work, and to be of assistance for the proper use of the various rescue-appliances, was an important subject. The men, in the first place, should be holders of first-aid certificates of the St. John Ambulance Association and thoroughly efficient in ambulance-work. This could only be obtained by constant practice, which was not possible under the system of attending classes in first-aid during a course of five or six lectures: and the mere fact of men passing examinations in first-aid was not sufficient to make them thoroughly efficient.

The branch of the Association, known as the St. John Ambulance Brigade, met all requirements to train ambulance-men thoroughly, as the rules of the brigade, to ensure efficiency, included provisions that the members must each be re-examined in first aid annually and attend a minimum of twelve drills or practices each year; and they also were required to be present at an annual inspection, when their efficiency was tested in drill and in the use of the stretcher.

The St. John Ambulance Brigade was formed for the purpose of carrying on the work begun by the Association in teaching first-aid students to be thoroughly efficient; and, at many collieries, there were now divisions and corps of the St. John Ambulance Brigade who were competent to take over the work of rescue-stations, and to be thoroughly trained in their use. The members of the brigade, being drilled, were accustomed to dis-

cipline, and well organized under officers who knew them and who could rely on them for any emergency. The system of having drills throughout the year, at which there was practice in first aid, rendered the men always efficient, as was required by the brigade-orders.

At those collieries where there were divisions of the brigade, the men took the greatest interest in the work, and there was a great competition amongst themselves to be efficient. There would consequently be little difficulty in extending their work to the handling of the various appliances used for rescue-work. Unless the workmen were thoroughly drilled in the manipulation of these appliances, there was a great danger that such appliances would not only be useless when most required, but they might be the means of a rescue-party losing their own lives. There should be constant practice in the use of the rescue-appliance, and the men must be accustomed to act under recognized leaders. These practices should be held occasionally down the pit, and when possible the parties should explore into old and disused workings so as to get accustomed to travel in rough ground and over falls.

The PRESIDENT (Mr. J. H. Merivale) moved a vote of thanks to Mr. Simonis for his interesting paper.

Mr. M. WALTON BROWN seconded the resolution, which was cordially approved.

Mr. E. SEYMOUR WOOD read the following paper on "Sinking through Magnesian Limestone and Yellow Sand by the Freezing-process at Dawdon Colliery, near Seaham Harbour, County Durham":—

SINKING THROUGH MAGNESIAN LIMESTONE AND YELLOW SAND BY THE FREEZING-PROCESS AT DAWDON COLLIERY, NEAR SEAHAM HARBOUR, COUNTY DURHAM.

By E. SEYMOUR WOOD, M.Inst.C.E., F.G.S.

I.—Introduction.

Dawdon colliery (Fig. 32), situated on the north-east coast, about a mile south of Seaham Harbour, will work the under-sea coal-royalty, leased by the Marquis of Londonderry from the Crown.

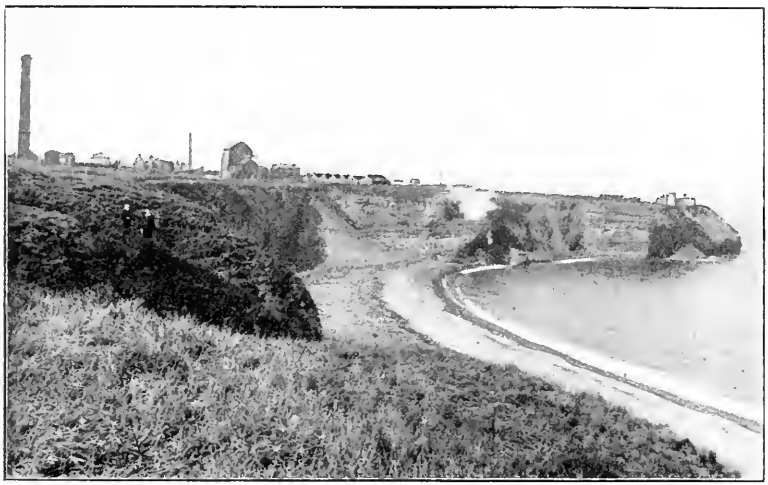


Fig. 32.—Dawdon Colliery.

II.—Geology.

The shafts are sunk on the eastern land-limit of the Durham coal-field. The Coal-measures crop out at the surface on the western side of the coal-field and dip towards the coast-line, where they are covered by Permian rocks, consisting of Magnesian Limestone, Marl Slates and Yellow Sand. The map (Fig. 1, Plate XXVII.) shows the area of the Permian rocks. The first section

(Fig. 2, Plate XXVII.) is taken from Harton colliery in the north to Castle Eden colliery in the south, the second section (Fig. 3, Plate XXVII.) from Moorsley colliery in the west to Dawdon colliery in the east, and they show the thicknesses of the Permian rocks as proved in the shafts of the neighbouring collieries.*

The difficulties in sinking shafts in this district arise from the occurrence of the Magnesian Limestone and the underlying Yellow Sand, the latter being usually found as a quicksand. Both of these strata contain large quantities of water.

Very difficult sinkings through this ground were experienced at the adjoining collieries of Haswell, Horden, Murton, Ryhope, Seaham, Seaton and South Hetton, all of which were sunk by the open-pit pumping process. In the sinking of the shafts at Marsden colliery, insurmountable difficulties were experienced with the pumping-plant system, and the shafts were finally sunk by the Kind-Chaudron system.

At Dawdon, the Coal-measures are overlain by the following thicknesses of strata:—Soil, 1 foot; boulder-clay, 5 feet 6 inches; old beach-gravel, 4 feet 6 inches; and Permian rocks, comprizing Magnesian Limestone, 356 feet 10½ inches; Marl Slates, 3 feet 1½ inches; and Yellow Sand, 92 feet 4 inches (Table III.).

The Magnesian Limestone, 356 feet 10½ inches thick, was, as usual, full of gullets giving off large quantities of water. Some of these gullets were undoubtedly connected with the sea, as the water issuing from them was salt. The water-level was affected by the rise and fall of the tides, a corresponding rise and fall of from 9 to 24 inches being found in the shaft water-level, 3 to 4 hours after high-water and low-water time at Seaham Harbour (Figs. 13 and 16, Plate XXX.). The largest feeder of water, met with in sinking through the Magnesian Limestone, was 6,075 gallons per minute in the Theresa shaft (Table VI.).

The Marl Slates, 3 feet 1½ inches thick, include the Fish-bed, 12½ inches thick, containing many interesting fossil-fish remains, notably:—*Pygopterus Humboldtii*, *Palaeoniscus (elegans, comptus* and *magnus)* and *Acrolepis magnus*.

The Yellow Sand, 92 feet 4 inches thick, is made up of blue-

* "The Marl Slate and Yellow Sands of Northumberland and Durham," by Prof. G. A. Lebour, *Trans. Inst. M. E.*, 1902, vol. xxiv., page 370.

grey sand, 75 feet; brown-grey sand, 17 feet 4 inches; and below the last-named lies grey stone, 1 foot thick.

The Coal-measures were found at the depth of 464 feet 4 inches.

III.—Sinking of Shafts with Pumping Machinery.

The first sod of the Theresa shaft was cut by the Marchioness of Londonderry, and the first sod of the Castlereagh shaft by Viscount Castlereagh on August 26th, 1899; and sinking was commenced on March 19th, 1900.

Theresa Shaft.—The Theresa shaft, 20 feet in diameter, was sunk to a depth of 350 feet by means of pumps, and lined with 225 feet of cast-iron tubbing and 96 feet of brick-walling.

The plant in the shaft comprized two pumping sets, 24 inches in diameter; one pumping set, 25 inches in diameter; and two Evans vertical sinking pumps, with steam-cylinders, 24 inches in diameter, and ram-plungers, 16 inches in diameter and 24 inches stroke, jointly capable of dealing with 7,000 gallons of water per minute. The water was pumped to the level of a drift, 90 feet below the surface, through which it ran to the sea-beach.

The largest feeder was 6,075 gallons per minute (Table VI.).

At a depth of 349 feet 6 inches, a drift was driven from this shaft to the Castlereagh shaft, to take the water from that shaft. The water was run down a bore-hole lined wih steel tubes, 9½ inches in diameter (Fig. 4, Plate XXVII.).

From the bottom of the shaft, three bore-holes were put down to test the thickness of the sand. It was found at a depth of 19 feet below the pit-bottom, and estimated at 84 feet thick.

The sinking operations in this shaft were stopped on May 17th, 1902, to allow the Castlereagh shaft to reach the same depth, and in order that both shafts might be sunk simultaneously through the sand.

Castlereagh Shaft.—The Castlereagh shaft, 20 feet in diameter, was sunk to a depth of 204 feet, and lined with 88 feet of cast-iron tubbing and 96 feet of brick-walling.

The water from this pit was run off by the bore-hole to the Theresa shaft (Fig. 4, Plate XXVII.). Two Evans pumps, similar to those in the other shaft, pumped any excess of water which did not drain through the bore-hole.

At a depth of 200 feet, the feeder of water was 5,750 gallons per minute, and, together with 1,300 gallons per minute flowing into the bottom of the Theresa shaft and drift, the total quantity of water being pumped was 7,050 gallons per minute (Table IV.).

The pumping of such a feeder of water before reaching the Yellow Sand, and the probability that the feeders would be greatly augmented in sinking through the sand-bed, led to the consideration of the question whether it would be desirable to erect additional pumping plant or to carry out the sinking of the shafts through the sand-bed in a frozen state. On serious deliberation, it was decided, after a conference with Mr. J. B. Simpson,

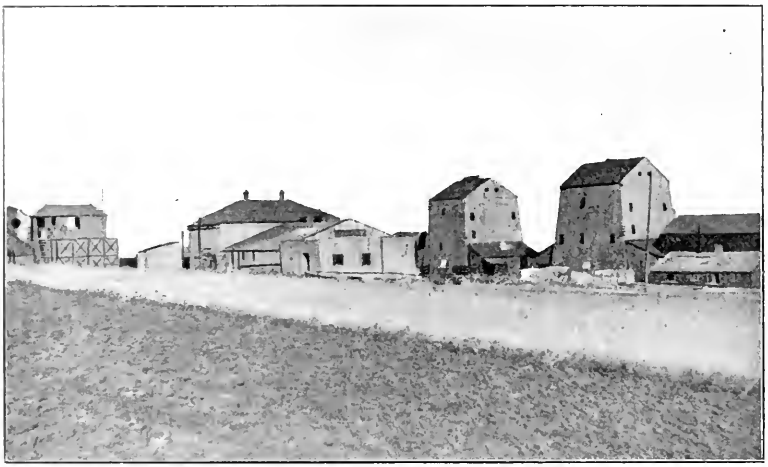


FIG. 33.—WEST SIDE OF SINKING-SHEDS AND FREEZING-HOUSE.

mining engineer, Bradley Hall, to adopt the freezing process; and sinking operations by pumping machinery were stopped on December 28th, 1902.

IV.—SINKING THE SHAFTS BY THE FREEZING PROCESS.

The shafts, each enclosed in a wooden shed, were handed over to the contractors, Messrs. Gebhardt & Koenig, Nordhausen, on April 20th, 1903 (Figs. 33 and 34). This firm undertook the freezing of the ground, through which the two shafts were being sunk and also the adjoining ground, to such an extent as to enable the owners of the colliery to carry out their sinking arrangements without the aid of pumps, until each shaft was sunk to a depth of 484 feet from the surface: also to establish a solid wall of ice round each shaft, and to maintain this wall

so long as should be necessary for the purpose of sinking the shafts and of renewing or of completing the existing or any further tubbing of the same.

The freezing process may be divided into four stages:—(1) The boring of the holes to receive the freezing-tubes and the insertion of the freezing-tubes; (2) the freezing of the strata, or the making and the maintaining of the ice-wall; (3) sinking within the ice-wall, and inserting all necessary tubbing; and (4) thawing the ice-wall and extracting the freezing-tubes.

FIG. 34.—EAST SIDE OF SINKING-SHEDS AND FREEZING-HOUSE.

(*a*).—*Boring the Holes.*

Previous to the boring of the holes to receive the freezing-tubes, a fore-shaft, *c*, 36 feet in diameter, was formed round each shaft, sunk to a depth of 8 feet and brick-lined, *d*, to the surface (Fig. 5, Plate XXVII.). Boring was started at this level, the holes being placed equidistant round a circle 30 feet in diameter (Figs. 6 and 7, Plate XXVIII.). The purposes of the fore-shaft (Fig. 5, Plate XXVII.) are as follows:—(1) To fix securely a tube, *e*, perfectly vertical, to act as a guide-pipe, the object being to keep the bore-holes as vertical as ever possible; and (2) to have a convenient chamber, *c*, in which all connections between the collectors and freezing-pipes, *f* and *g*, can be made, and from which each individual freezing-tube can be controlled;

and to take observations of the temperatures and watch the circulation of the brine in the freezing-tubes.

Castlereagh Shaft.—Boring was commenced at the Castlereagh shaft on May 20th, 1903, with three boring-machines, each driven by a vertical engine. Three small Worthington pumps were used for pumping water into the bore-holes, and two steam-winches for lifting and lowering the rods and tubes.

Twenty-eight bore-holes were marked off on a circle 30 feet in diameter surrounding the shaft (Fig. 6, Plate XXVIII.). Trouble was met with at Nos. 7 and 8 holes, necessitating the boring of extra holes, Nos. 7*a* and 8*a*, the whole being completed by April 7th, 1904. The depth of each of the holes was 484 feet. The average time occupied in boring each hole was 24 days (Table I.)

TABLE I.—TIME OCCUPIED IN BORING THE HOLES TO RECEIVE THE FREEZING-TUBES AT THE CASTLEREAGH SHAFT.

No. of Bore-hole.	Boring		Time.	No. of Bore-hole.	Boring		Time.
	Commenced.	Finished.			Commenced.	Finished.	
			Days.				Days.
1	1903, May 20	1903, June 10	21	15	1903, July 26	1903, Aug. 14	20
2	,, Oct. 14	,, Nov. 6	23	16	,, July 2	,, July 25	24
3	1904, Jan. 10	1904, Jan. 28	18	17	,, May 29	,, July 1	33
4	1903, Dec. 1	,, Jan. 6	37	18	,, Nov. 3	,, Nov. 27	24
5	,, Sept. 8	1903, Oct. 9	32	19	,, Sept. 9	,, Oct. 7	28
6	,, July 30	,, Aug. 30	31	20	,, Nov. 28	,, Dec. 23	26
7	,, July 8	,, July 28	21	21	1904, Jan. 6	1904, Feb. 7	23
7*a*	1904, Mar. 23	1904, April 7	15	22	1903, Dec. 24	,, Jan. 17	24
8	1903, June 12	1903, July 6	25	23	,, Nov. 8	1903, Dec. 3	26
8*a*	1904, Feb. 19	1904, Mar. 3	14	24	,, Oct. 8	,, Oct. 31	23
9	1903, May 20	1903, June 11	22	25	,, Aug. 22	,, Sept. 13	23
10	1904. Jan. 7	1904, Jan. 31	25	26	,, July 22	,, Aug. 20	30
11	1903, Dec. 5	,, Jan. 1	28	27	,, July 1	,, July 21	21
12	,, Nov. 2	1903, Nov. 29	28	28	,, June 11	,, June 30	20
13	,, Sept. 26	,, Oct. 18	22				
14	,, Aug. 14	,, Sept. 4	21		Average time		24

Theresa Shaft.—Boring was commenced on June 23rd, 1903, and was completed on April 22nd, 1904. Four boring-machines were used of the free-fall type, four small pumps for pumping water to the bore-holes, and two belt-driven winches and one steam-winch for lifting or lowering rods or tubes.

Twenty-eight holes were marked out, as at the Castlereagh shaft, and, owing to difficulties met with in the broken limestone, three attempts were made before No. 14*a* hole was finished (Fig. 7, Plate XXVIII.).

The average time occupied in boring each hole to a depth of 484 feet was 24 days (Table II.) The quantity of water used for boring was about 11,000 gallons per hour.

TABLE II.—TIME OCCUPIED IN BORING THE HOLES TO RECEIVE THE FREEZING-TUBES AT THE THERESA SHAFT.

No. of Bore-hole.	Boring		Time.	No. of Bore-hole.	Boring		Time.
	Commenced.	Finished.			Commenced.	Finished.	
			Days.				Days.
1	1903, June 23	1903, July 16	24	15	1903, Oct. 12	1903, Oct. 30	18
2	,, July 17	,, Aug. 6	21	16	,, Nov. 16	,, Dec. 3	18
3	,, Aug. 8	,, Aug. 28	20	17	,, Dec. 12	1904, Feb. 5	41
4	,, Sept. 1	,, Sept. 23	22	18	1904, Feb. 16	,, Mar. 9	22
5	1904, Feb. 7	1904, Feb. 24	18	19	,, Mar. 9	,, Apr. 22	39
6	,, Jan. 5	,, Jan. 24	19	20	1903, Nov. 4	1903, Nov. 24	20
7	1903, Nov. 30	1903, Dec. 19	20	21	,, Aug. 4	,, Aug. 31	27
8	,, Oct. 28	,, Nov. 21	24	22	,, Oct. 9	,, Oct. 27	18
9	,, Sept. 27	,, Oct. 20	23	23	,, Dec. 21	1904, Mar. 3	31
10	,, Aug. 30	,, Sept. 17	19	24	1904, Mar. 3	,, Mar. 25	22
11	,, July 13	1904, April 6	37	25	,, Jan. 28	,, Feb. 20	24
12	,, June 23	1903, July 12	20	26	1903, Nov. 23	1903, Dec. 13	20
13	,, July 28	,, Aug. 16	20	27	,, Oct. 21	,, Nov. 10	21
14	,, Aug. 18	,, Oct. 3	20	28	,, Sept. 8	,, Oct. 9	32
14*a*	,, Dec. 9	,, Dec. 20	11				
14*b*	,, Dec. 22	1904, Jan. 18	28		Average time ...	...	24

All bore-rods and chisels were made of steel, with a hole passing down the centre for the circulation of water to wash out the borings.

All the holes were bored to a depth of about 130 feet with a chisel, $9\frac{7}{8}$ inches in diameter, and then lined with tubes, $9\frac{1}{2}$ inches in diameter. From that point, the holes were bored with a chisel 8 inches in diameter, inner tubes, $7\frac{1}{2}$ inches in diameter, being put down from the surface. The holes were carried down to a depth of 460 feet, entering into the Coal-measures, where the sand was cut off in most of the holes. The remaining depth of 24 feet was bored with a chisel, $6\frac{1}{2}$ inches in diameter. When the full depth was attained, a lining of tubes, $6\frac{1}{4}$ inches in diameter, was placed inside the whole length of each bore-hole. This lining was necessary to secure the whole depth of the hole, to keep it clean, and to act as a guide when introducing the freezing-tubes.

(*b*).—*Plumbing the Bore-holes.*

The plumbing of the holes was done from a scaffold, *h*, 29 feet above the bore-holes. The plumb, connected by a wire, *i*, passing

over a small pulley, *j*, to a drum, *k*, was set to the centre of the hole, lowered down in 33 feet lengths, and the deviation measured and calculated (Fig. 5, Plate XXVII.). This system of plumbing was proved to be absolutely unreliable (Figs. 6 and 7, Plate XXVIII., showing the deviation of the bore-holes). A more perfect system of surveying and finding the exact position or deviation of a bore-hole for this purpose could be advantageously employed.

It is most important that the bore-holes should be as nearly vertical as ever possible. This was overcome to some extent at Dawdon by the use of a strong vertical pipe, *c*, in the fore-shaft, as a guide, and by using very strong lining tubes. If the hole becomes much out of plumb, these lining tubes gradually work themselves fast, and cannot be turned or twisted round in the hole.

(*c*).—*Freezing-tubes.*

The freezing-tubes (Fig. 8, Plate XXVIII.) comprize:—(1) An outer tube, *a*, 5 inches in diameter, in lengths of 16 feet; they are inserted to the whole depth of the bore-hole, and the bottom end is closed. (2) An inner tube, *b*, $2\frac{1}{2}$ inches in diameter, reaching to within 33 feet of the bottom of the tubbing at each shaft, where a special double nipple, *e*, with an inside thread, was placed, making a connection with the outer tube. The air-space, *d*, formed between the outer tube, *a*, and the inner tube, *b*, down to this point acts as an isolating chamber, and prevents any direct connection with the strata, thus protecting the tubbing from severe frost. An expansion-joint, *e*, was placed midway between the double nipple and the bottom of the tube in each hole. As each length of the above freezing-tubes was put down into the bore-hole, it was tested under a pressure of 30 atmospheres. (3) A central tube, *f*, $1\frac{1}{4}$ inches in diameter, open at the bottom, was placed within the tubes, *a* and *b*, to within 3 feet of the total depth.

After the whole of the freezing-tubes had been inserted, the lining-tubes were withdrawn, the inner tubes being taken out first. The freezing-tubes were then connected to the inner and outer collectors for the circulation of the brine.

(*d*).—*The Freezing of the Strata or Making and Maintaining the Ice-wall.*

The freezing-plant, capable of 500,000 calories or about 2,000,000 British thermal units per hour, consisted of two steam-

engines of 135 horsepower, driving four ammonia-compressors (Figs. 9 and 10, Plate XXVIII, and Figs. 35 and 36). One steam-engine, A, with a cylinder $19\frac{3}{4}$ inches in diameter and $31\frac{1}{2}$ inches stroke, and fitted with Rider expansion-gear, ran at 72 revolutions per minute. The other steam-engine, B, with a cylinder, $19\frac{3}{4}$ inches in diameter and $19\frac{3}{4}$ inches stroke, and fitted with Meyer expansion-gear, ran at 120 revolutions per minute. The steam had a pressure of 100 pounds per square inch. Both of these engines transmitted their power by belting to a shaft, C, by which two compressors, F and G, were driven. Two compressors, D and

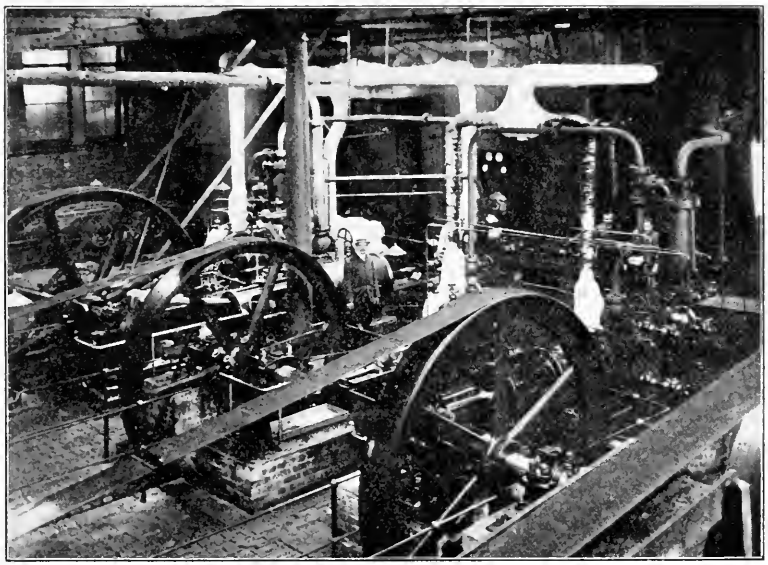


FIG. 35.—FREEZING-PLANT.

E, were coupled direct to one steam-engine, A. The ammonia-compressors were of the following dimensions:—D, one cylinder, 13 inches in diameter and 24 inches stroke; E, one cylinder, 11 inches in diameter and $31\frac{1}{2}$ inches stroke; F, one cylinder, 10 inches in diameter and 20 inches stroke; and G, one cylinder, 10 inches in diameter and 20 inches stroke. All the ammonia-compressors were double-acting, with two cylindrical suction-valves on the right side and two pressure valves on the left side.

The freezing system is the same as in all ammonia-plants (Fig. 11, Plate XXVIII.). The ammonia, at a pressure of 150

pounds per square inch, was circulated through the spiral pipes, *b*, in five cooling-condensers, *c*, and liquefied by the extraction of heat, effected by circulating through the condensers (Fig. 37) 14,000 gallons of cooling water per hour. The liquid ammonia passed to four refrigerating-tanks, *d*, containing 20,000 gallons of brine, expanded through an expansion-valve, *e*, and circulated through 2,000 feet of spiral tubing, *f*, in each tank, reducing the temperature of the brine to −17° Cent. (1·4° Fahr.), and was then conveyed to the compressors, *a*, to be compressed again to 150 pounds per square inch. The first charge of liquid ammonia placed in the compressors weighed 16 cwts.

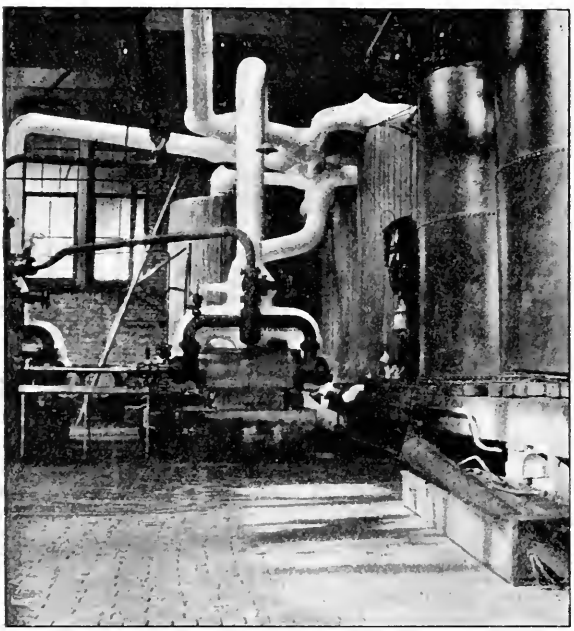


Fig. 36.—Ammonia-compressor and Refrigerating-tanks.

The cooling water for use in the condensers was pumped from the sea, and its temperature varied from 5° to 18° Cent. (41° to 64° Fahr.), according to the season of the year (Fig. 12, Plate XXIX.).

The brine, a solution of 26 per cent. of chloride of magnesia, at a temperature of −17° Cent. (1·4° Fahr.), the medium used to extract the heat from the strata and to freeze the ground, was pumped from the refrigerators, *d*, by two quadruple-acting pumps, *g*, with steam-cylinders $7\frac{1}{4}$ inches in diameter, pump-cylinders $6\frac{3}{4}$ inches in diameter and 6 inches stroke, circulating 330 gallons of brine per minute, through the collectors, *h*, down the central tubes, returning up the freezing-tubes in the shaft to the collectors, *i*, and back to the refrigerators to be re-cooled.

Castlereagh Shaft.—The freezing plant was connected to the Castlereagh shaft on April 22nd, 1904, 18 holes being put into circulation, and the remaining 11 holes were put into circulation on the following day.

The temperature of the brine going to the pit was −13·5° Cent. (7·7° Fahr.) and on returning it was −6° Cent. (21·2° Fahr.). The temperature of the brine on the closing of the ice-wall and at the commencement of the sinking of the shaft on November 7th, 1904, was −17° Cent. (1·4° Fahr.) and on returning it was −13° Cent. (8·6° Fahr.).

On June 9th, 1904, careful measurements were made, showing the position of the water in the shaft, and it was found

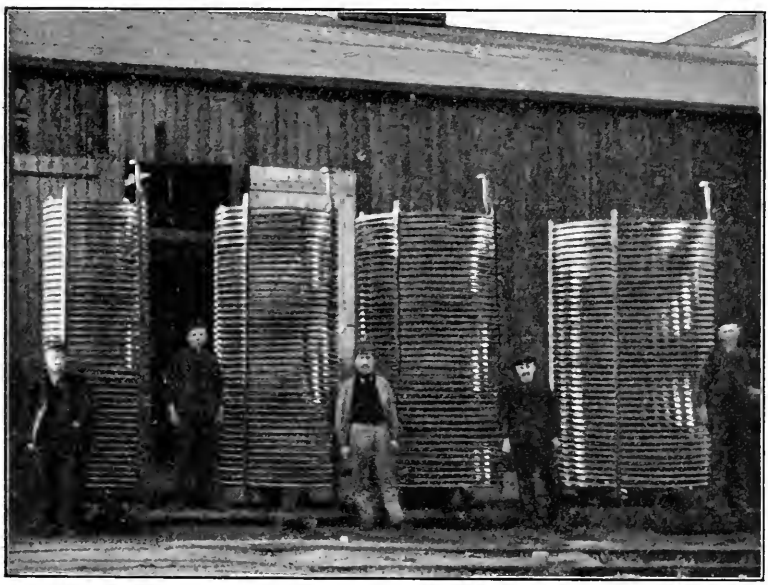


FIG. 37.—SPIRAL TUBES FOR COOLING-CONDENSERS AND REFRIGERATION-TANKS.

that the water-level was influenced by the height of the sea-tides (Fig. 13, Plate XXX.). The water-level varied from 13½ to 23½ inches and was felt in the shaft 2 to 4 hours after high water and low water at Seaham Harbour.

It was decided to fill the bottom of the shaft with concrete, so as to stop the rise and fall of water in the shaft, with its accompanying displacement of water, which might delay the formation of the ice-wall. From July 20th to 22nd, 1904, 190

tons of concrete were put down the shaft, filling the space above the level of the bottom crib of tubbing, and this stopped the water flow (Fig. 14, Plate XXX.). There was no further variation of water-level in the shaft until the ice-wall closed, when a rise of about $\frac{1}{2}$ inch per day was recorded (Fig. 15, Plate XXX.).

The temperature of the water in the shaft, when freezing commenced, was 9° Cent. (48·2° Fahr.), and it decreased to −0·5° Cent. (31·1° Fahr.) at the bottom and 1° Cent. (33·8° Fahr.) at the top of the shaft, during the formation of the ice-wall.

On October 12th, 1904, when the water was drawn out of the shaft, it was found that ice had formed on the tubbing for about 40 feet above the concrete: it was thin at the top, thickening towards the bottom to about 3 feet thick on the concrete and round the sides of the tubbing.

Sinking was then commenced in this shaft.

The following difficulties with the freezing-tubes were encountered:—On October 31st, 1904, the brine in No. 15 hole was found to be circulating indifferently: the central tubes were taken out, and they were found to be broken off below the expansion-piece in the freezing-tube at a depth of about 320 feet. Repeated attempts were made to draw the broken length; and eventually some of the drawing instruments were broken off and lost in the hole. On April 9th, 1905, a freezing-tube, 3 inches in diameter, with a closed end and a central tube, were placed within the old freezing-tube, as far as the hole was open; and circulation was maintained by this means from that date. This freezing-tube, *a*, was found later on in the side of the sinking pit and had to be cut out (Fig. 6, Plate XXVIII.). The broken central tube and drawing instruments were found in the portion of the tube that was cut out.

On November 24th, 1904, the circulation of the brine stopped in No. 16 hole. The whole of the central tubes were withdrawn; and on cleaning the brine out of the freezing-tube it was found that the sludge-pump could not be lowered down further than the expansion-piece in the freezing-tube, and to get the rods past the obstruction, the double nipple in the freezing-tube was bored out to a larger size. On reaching the expansion-joint, it was thought that the freezing-tube was broken. A special instrument was then introduced, the broken freezing-tube was bored through, and a hole large enough to take a freezing-tube,

3 inches in diameter, was continued through the Magnesian Limestone and Yellow Sand, in the ice-wall, down to the Coal-measures. On the completion of this hole, it was found that the freezing-tube, 3 inches in diameter, could not be made to pass through the hole drilled in the old freezing-tube. On June 19th, 1905, when sinking through the drift between the Castlereagh and the Theresa shafts, on a level with the obstruction in No. 16 freezing-tube, a hole was cut back in the Magnesian Limestone near the drift and the tube, *b*, was exposed (Fig. 6, Plate XXVIII). It was then found that the freezing-tube had deviated from the vertical at the expansion-joint, and that the tube underneath that joint had been bored through. The expanding piece and part of the tube beneath were cut out (Fig. 38), a fresh hole was bored from that point in the ice-wall to a depth of 460 feet, lined with freezing tubes, 3 inches in diameter, from the surface, connected to the collectors, and circulation was maintained in it until the end of the freezing.

FIG. 38.—No. 16 FREEZING-TUBE.

The length of time required to form the ice-wall in this pit was 185 days. The ice-wall was maintained for 353 days; the brine was cut off from the shaft on October 19th, 1905; the total time of freezing at this shaft being 538 days.

Theresa Shaft.—The freezing plant was connected to the Theresa shaft on June 10th, 1904, three holes being put in circulation, and on July 18th, the whole of the freezing-tubes were put in circulation. The temperature of the brine going to the pit was −13° Cent. (8·6° Fahr.) and on returning −8·5° Cent. (16·7° Fahr.).

The water-level in this shaft was also affected by high tides and low tides at sea, the displacement being almost the same as at the Castlereagh shaft (Fig. 16, Plate XXX.). The water in this pit was tested by taking samples; it was found to contain 7 per cent. of salt at the bottom of the pit and 3 per cent. at

water-level: and, after the water had been pumped out of this pit for two days, it was found to remain uniform at 3 per cent. throughout the shaft.

On August 31st, 1904, the bottom of the shaft was filled with débris, A, to above the level of the bottom crib of tubbing (Fig. 17, Plate XXXI.). After allowing time for it to settle, 90 tons of concrete, B, were deposited, on September 8th, 1904, on the top of the rubbish so as to stop the rise and fall of water, as influenced by the tides.

On November 1st, 1904, 15 feet of water was drawn out of the shaft to test whether the ice-wall was formed, but the level of the water gradually rose up to November 7th, when a further depth of 35 feet of water was drawn out (Fig. 18, Plate XXXI.): and from this depth, the water commenced to rise very rapidly till it reached water-level. The rise and fall of the water-level again proved that the ice-wall was not formed; and on November 21st, 1904, 14 tons of concrete, C, were put down the shaft (Fig. 17, Plate XXXI.). As the rise and fall of water still continued, on November 30th, 1904, 25 tons of concrete, D, were put down the shaft, and the rise and fall of the water then ceased (Fig. 18, Plate XXXI.).

On January 18th, 1905, another attempt was made to test the ice-wall at this shaft, and the water was drawn out to a depth of 27 feet 4½ inches. The water-level, thereafter, gradually rose, until on January 28th, 1905, it had risen 3 feet or 4 inches per day (Fig. 19, Plate XXXI.). On January 28th, 1905, 12 feet 4 inches of water was drawn out; the water then gradually rose until on February 3rd, 1905, a rise of 7 feet 8 inches, or 15 inches per day, was recorded. On February 3rd, 1905, 15 feet 6 inches of water was drawn out; and the water rose 5 feet 9 inches between then and February 6th, or 24 inches per day. On February 6th, 1905, a further 21 feet 0½ inch was drawn out, and the water rose gradually, at the rate of 4 feet per day or 352 gallons per hour, until February 21st, 1905.

It was thought that this gradual rise could only be due to one of two causes: (1) Leakages in the tubbing; or (2) some defect in the ice-wall, towards the bottom of the shaft, allowing the circulation of water from the bottom.

It was decided to ascertain whether there was any leakage from the tubbing. On February 21st, 1905, the water was

drawn out, and careful observations were taken of the ice-deposit on the sides of the tubbing as the water-level was lowered. A bare place, *ab* (that is a portion of the tubbing not covered with ice), was found to run for some considerable depth on the west side of the shaft at the position of No. 22 bore-hole (Figs. 22 and 23, Plate XXXII.). On reaching a depth of 132 feet, a feeder of 1,000 gallons per minute, issuing from the bottom of the shaft, proved conclusively that the ice-wall had not been formed.

The shaft was filled as quickly as possible with water by diverting the overflow from the cooling tanks, so as to minimize, as far as possible, the breach in the ice-wall. It was then found that the water-level was again influenced by the tides. Fig. 19 (Plate XXXI.) records the variations of the level of the water from January 15th up to and including March 4th, 1905. On February 27th, 1905, 90 tons of concrete, E, were put into the shaft, and the rise and fall of water was stopped (Fig. 17, Plate XXXI.).

From the diagram (Fig. 29, Plate XXXIII.) showing the temperatures of the brine going down the central tube and returning to the surface, the loss of temperature in the strata at each hole, and from observations of the ice-deposit exposed on the sides of the tubbing on February 21st, 1905, it was thought that the breach in the ice-wall was in the vicinity of No. 22 hole on the west side of the shaft. To strengthen the ice-wall at this point, it was decided to put down a new bore-hole, *a*, adjacent to No. 22 hole, in the ice-wall, and to fit it with freezing-tubes (Fig. 7, Plate XXVIII.). On May 27th, 1905, this hole was commenced; but the frost was so severe in the ice-wall that, despite every precaution, the rods, chisels, etc., were many times frozen fast in the hole and it had to be overbored. This hole was eventually abandoned at a depth of 284 feet, on August 12th, 1905.

On August 10th, 1905, the shaft was again tested, and all the water was drawn out. It was found that the ice-wall had formed, the bottom of the shaft showed a mass of ice, 3 feet 6 inches thick all round the tubbing (Figs. 20 and 21, Plate XXXII.). This diagram shows clearly the action of the double nipple and isolation-chamber, *c*, as the thickness of the ice increases, where the freezing-tubes come into direct contact with the strata, and decreases where the isolation-chamber comes into effect.

On clearing away the ice in the bottom of the shaft, sinking was commenced on August 14th, 1905. The temperature of the brine going to the shaft was −19° Cent. (−2·2° Fahr.), and it was returning at a temperature of −16° Cent. (3·2° Fahr.).

The temperature of the water in this shaft at the commencement of the freezing was 11° Cent. (51·8° Fahr.), and it decreased to 0·5° Cent. (32·9° Fahr.) on the formation of the ice-wall.

The circulation of brine to this shaft was cut off on February 16th, 1906. The total time of freezing and maintaining the ice-wall was as follows:—Forming the ice-wall, 392 days; maintaining the ice-wall, while sinking, etc., 186 days: the total time of freezing being 578 days. The length of time taken to freeze this shaft was increased by drawing out the water from the shaft before the ice-wall was sufficiently strong to stand the pressure put on it.

(*c*).—*Sinking in the Frozen Ground.*

Through the limestone, naturally hard but with its hardness intensified by the frost, explosives were used to blast out the rock. Great care was required in placing the shot-holes and regulating the quantity of explosive used, to prevent any breakage of the freezing-tubes surrounding the shaft and so cause a leakage of brine, which might damage the ice-wall. The following shot-firing regulations were adopted:—

A. Black compressed powder must be used for all shots.

B. Sumping holes must not be more than 50 inches deep. Not more than 12 inches of powder, including the primer, may be used in any hole. The shots must be fired by electricity, and not more than three holes may be fired at one time.

C. Caunch or side holes must not be placed nearer than 12 inches to the side of the shaft, and not more than 40 inches deep. Not more than 6 inches of powder, including the primer, may be used in any hole. The holes must be drilled at an angle of 17 to 20 degrees towards the centre of the shaft (Figs. 24 and 25, Plate XXXII). Not more than one shot may be fired at one time.

The preceding regulations necessitated the drilling of a large number of shot-holes. The work was expedited by drilling them with Larmuth rock-drills, driven by compressed air. The shot-holes were kept from freezing, either by using a solution of 6 per cent. of caustic soda or 10 per cent. of washing soda. The shot-firing regulations also entailed a great amount of shearing-back of rock, to dress the shaft-sides straight down. The Magnesian Limestone in some places was so strong

that holes on the side had to be drilled by rock-drilling machines and the stone removed by stub and feather. Little Jap hand pneumatic rock-drilling machines were also used for this work and gave very good results in dry ground. To protect the sinkers' hands from frost-bite and their eyes from being cut by sharp pieces of rock and sand from pick and drill-rod points, leather gloves and gauze-goggles were provided.

Castlereagh Shaft.—After all the water had been drawn out of the Castlereagh shaft, sinking was commenced on October 17th, 1905. All ice and soft concrete were removed from the bottom. Eight holes were drilled in the concrete, through specially prepared stuffing-boxes that could be shut, should there be any inrush of water up the holes (Fig. 26, Plate XXXII.) to

TABLE III.—SECTION OF STRATA SUNK THROUGH IN THE CASTLEREAGH SHAFT, DAWDON COLLIERY.

No.	Description of Strata.	Thickness of Strata. Ft.	Ins.	Depth from Surface. Ft.	Ins.
	Alluvium—				
1	Soil	1	0	1	0
2	Clay	5	6	6	6
3	Gravel	4	6	11	0
	Magnesian Limestone—				
4	Strong marl, with limestone-girdles	50	10	61	10
5	Limestone, with strong marl-partings	32	7	94	5
6	Marl, with gullets	84	7	179	0
7	Hard grey limestone	34	6	213	6
8	Yellow limestone, with red marl ...	13	2	226	8
9	Hard grey limestone	65	7	292	3
10	Grey and yellow limestone ...	17	6	309	9
11	Yellow limestone...	22	0	331	9
12	Hard grey limestone	5	6	337	3
13	Hard grey limestone, in panels	30	7½	367	10½
	Marl Slate— Ft. Ins.				
14	Soft shale .. 0 1¼				
15	Hard shale... 1 11¾				
		2	1	369	11½
16	Fish-bed	1	0½	371	0
	Yellow Sand—				
17	Blue-grey sand ...	75	0	446	0
18	Brown-grey sand ...	17	4	463	4
	Coal-measures—				
19	Very hard grey post-girdle ...	1	0	464	4
20	Dark-grey shale, with red shale-bands	21	0	485	4
21	COAL	0	3	485	7
22	Grey shale	2	5	488	0
23	COAL	4	4½	492	4½
24	Grey post	2	2½	494	7
25	Seggar-clay ...	11	8	506	3
26	COAL	0	10	507	1
27	Grey shale ...	5	9	512	10
28	Dark-grey shale ...	2	10	515	8
29	COAL	0	1¾	515	9¾
30	Dark-grey shale ...	0	10¼	516	8
31	Grey post, with shale panels ...	9	9	526	5
32	Very hard grey post	1	1	527	6
33	Grey post, with shale partings ...	12	0	539	6
34	Dark-grey shale ...	0	9	540	3
35	Grey shale	0	4	540	7
36	Post-girdle ...	0	2	540	9
37	Grey shale	0	3	541	0
	Ft. Ins.				
38	COAL ... 1 5				
39	Stone . 0 1½				
40	COAL ... 1 10½				
		3	5	544	5
41	Seggar-clay .	4	5	548	10
42	Grey shale	3	3	552	1
43	COAL	0	7	552	8
44	Seggar-clay ...	10	10	563	6

ascertain whether the strata below the concrete were frozen. These holes were put down about 4 feet into the rock. Subsequently, two holes were put down to a depth of 15 feet into the rock. The whole of the concrete was then removed, and sinking was commenced in the frozen strata at a depth of 203 feet 2 inches in the Magnesian Limestone, on October 31st, 1905 (Table III.).

At this depth, the ice-wall was not frozen solid across the shaft, there being an unfrozen core in the centre. Diagrams (Figs. 27 and 28, Plate XXXII.) were taken to show the ice-ring inside the shaft on December 9th, 1905, and January 8th, 1906. A fortnight later the whole of the shaft-bottom was frozen solid.

As is usual in Magnesian Limestone, large gullets were found; and as these were invariably filled with ice, they showed the previous presence of large quantities of water.

The progress of the sinking through the Magnesian Limestone was slow, owing to the shot-firing restrictions. The average progress in rock was 5½ feet per week, and including sinking, and tubbing and wedging, etc., it was 4½ feet per week. In the Yellow Sand, the progress was 20 feet 10 inches per week, and including sinking, and tubbing and wedging, etc., it was 7½ feet per week.

TABLE IV. – ACCOUNT OF THE CAST-IRON WEDGING-CRIBS IN THE CASTLEREAGH SHAFT, DAWDON COLLIERY.

No. of Crib.	Description of Strata forming the Bed of the Crib.	Depth from Surface. Ft.	Ins.	Remarks.
1	Marl, with gullets	140	2	Water-feeders reduced from 1,520 to 735 gallons per minute.
2	Hard grey limestone	184	4	Water-feeders reduced from 4,580 to 380 gallons per minute.
3	Hard grey limestone	200	8	Water-feeders reduced from 5,750 to 4,050 gallons per minute.
4	Hard grey limestone, frozen ...	259	3	Frozen ground.
5	Yellow limestone, frozen ...	319	5	Do.
6	Hard grey limestone, in panels, frozen	357	0	Do.
7	Blue-grey sand, frozen	390	4	Do.
8	Blue-grey sand, frozen	432	4	Do.
9	Dark-grey shale, with red shale-bands, frozen	468	4	Do.
10	Grey shale	510	6	—
11 and 12	Grey post, with shale-partings ...	535	1	Double wedging-crib.

The making of the crib-beds, laying the cribs and putting on the tubbing and wedging of the same were rapidly done, the dryness of the pit and other conditions being very favourable for this work (Table IV.)

On approaching the drift from the Theresa shaft, bore-holes were put down to prove that it was properly frozen before holing into it. The top portion of the drift was found to be solid ice. The drift (Fig. 39), filled with sand frozen hard, was eventually timbered off.

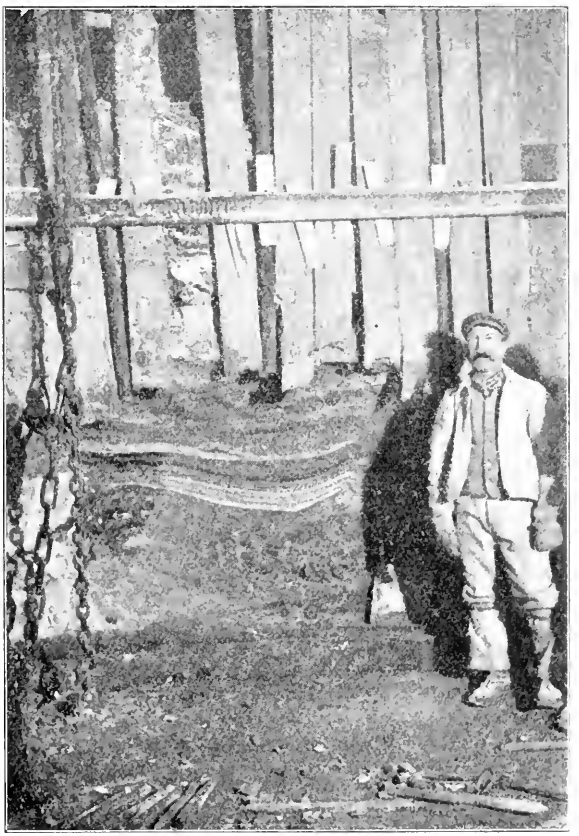


Fig. 39.—Drift between the Castlereagh and Theresa Shafts, as found in the Castlereagh Shaft.

When working at the level of the drift, the opportunity was taken to cut out the rock and to expose No. 16 freezing-tube, part of which was eventually cut out at that point (Fig. 38). A new hole was bored from the surface, through the top freezing-tubes and through the ice-wall, into the Coal-measures, and small freezing-tubes were inserted in it.

When the last length of tubbing had been inserted, and wedged in the Magnesian Limestone at a depth of 356 feet $11\frac{3}{4}$ inches before entering the sand, bore-holes were put down

with rock-drills, through special stuffing-boxes (Fig. 26, Plate XXXII.), to avoid an inrush of water, to prove whether the sand was frozen. Five bore-holes were attempted: Nos. 1 and 5 holes were lost through the rods freezing in the holes; No. 2 hole was bored 51 feet 2 inches; No. 3 hole, 18 feet 6 inches; and No. 4 hole, 25 feet. The strata passed through in No. 2 hole comprized limestone, 8½ feet; fish-bed and shale, 3½ feet; and into frozen sand, 39 feet.

On July 22nd, 1905, the sand was struck at a depth of 371 feet, and found to be frozen hard. So great was the intensity of the freezing, that the sand resembled hard grey freestone, although pieces readily crumbled away when held for a short while in the hand. On being exposed to the atmosphere the sand soon became soft and fell to pieces. In the shaft-bottom, the frozen sand was so hard that blasting had to be continued throughout the deposit. The upper portion of the frozen sand was tested, and found to contain 12 per cent. of water. Some of the ground passed through towards the bottom contained a very much larger percentage of water, and girdles of ice intermingled with the sand exposed in the sinking, proved the previous presence of free water. The temperature of the frozen sand in the bottom of the pit was −14° Cent. (6·8° Fahr.).

The Yellow Sand was found of two colours: blue-grey sand, 75 feet thick; and brown-grey sand, 17 feet 4 inches thick.

At the bottom of the sand, lying unconformably on the Coal-measures, there was a hard irregular mass, about 1 foot thick, which on examination was found to contain a large amount of calcite and secondary silica.

On entering the sand, the sides were carefully protected with heavy wooden cribs and backing deals. After sinking to a depth of 24 feet, it was deemed advisable to protect the portion already sunk; and a crib-bed was made in the frozen sand at a depth of 390 feet 4 inches. No. 15 freezing-tube, *a*, was exposed, on cutting back to form this crib-bed, it was cut out altogether beneath the crib-bed, and the lost boring-tool and cutter were recovered (Fig. 6, Plate XXVIII.). A metal crib and foundation-course, 18 inches wide, was laid, and a lift of tubbing, packed with concrete behind, was run up to the bottom crib in the Magnesian Limestone. On completion, a further depth of 51 feet was sunk and a second crib-bed was made at a depth of 432 feet 4 inches

in the frozen sand; and a metal crib and foundation-course, 18 inches wide, was laid, and a lift of tubbing, backed with concrete was inserted.

On August 2nd, 1905, the Yellow Sand was passed through, and the sinking entered the dark-grey shale of the Coal-measures. The sinking was continued 7 feet into the Coal-measures; and a crib-bed was formed in the frozen ground at a depth of 468 feet 4 inches. A metal crib and foundation-course, 15 inches wide, was laid, a length of tubbing, backed with concrete, was put in, and the sand was closed off. On shearing back, to make the last named crib-bed, Nos. 6 and 7 freezing-pipes were exposed: No. 6 pipe, *c*, just cleared the metal crib, but No. 7 pipe, *d*, had to be cut out to allow the metal crib to be laid (Fig. 6, Plate XXVIII.).

Sinking was resumed to a further depth of 49 feet, and the bottom of the ice-wall or frozen ground passed through (Fig. 30, Plate XXXIII.).

On August 18th, 1905, a crib-bed was laid at a depth of 510 feet 6 inches, and a lift of tubbing was built from it.

The bottom foundation crib-beds were made at a depth of 535 feet 1 inch. Two metal foundation-cribs, the bottom one 18 inches wide and the top one 22 inches wide, were laid, and the tubbing was completed (Fig. 31, Plate XXXIV.).

The section of the metal tubbing put into the shafts was $\frac{7}{8}$ inch thick at the water level, increasing $\frac{1}{8}$ inch for each 60 feet in depth, the bottom length being $1\frac{1}{2}$ inches thick.

On September 25th, 1905, when sinking through the Coal-measures in the frozen ground, at a depth of about 486 feet while drilling sump-holes, one of the holes struck a feeder of water under sufficient pressure to force a jet of water 20 feet up the shaft and of very low temperature. The hole was plugged, but when the pressure was allowed to run off, the quantity of water was found to be very small. It was thought that the water had come from a "pocket," which had not been frozen, and that it had been subjected to great pressure owing to the expansion of the frozen ground.

Theresa Pit.—Sinking in the frozen ground was effected in the Theresa shaft on somewhat the same lines as at the Castlereagh shaft.

The sinkers were sent into this shaft on August 14th, 1905,

to take out the ice on the sides of the tubbing and in the bottom of the shaft (Fig. 40). When all the ice had been removed, three holes were bored through the concrete to ascertain whether the underlying ground was thoroughly frozen. Leading bore-holes were kept in advance, until the drift to the Castlereagh shaft was passed and the Magnesian Limestone struck at a depth of 354 feet. Three holes were bored in the bottom of the pit to prove the thickness of the Magnesian Limestone, and they were stopped at a depth of 15 feet (Table V.).

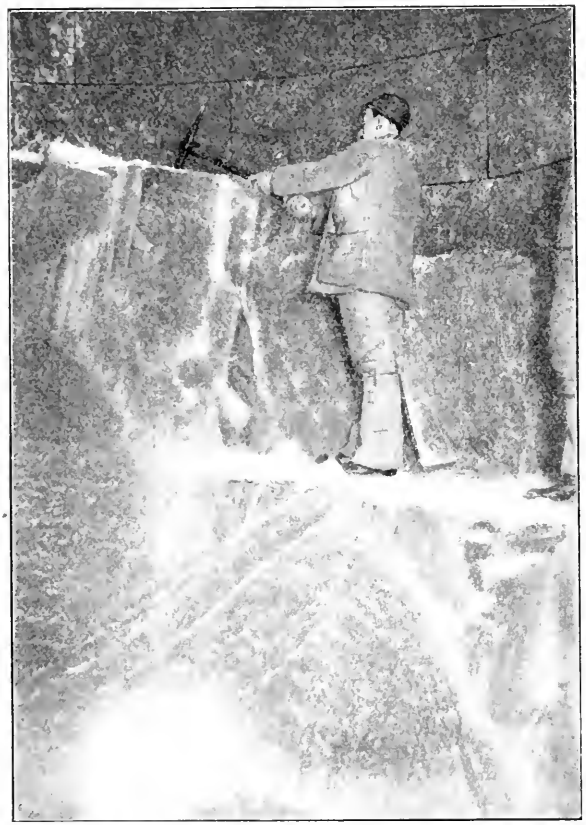


Fig. 40.—Sinker removing Ice-wall in the Theresa Shaft.

On sinking 11 feet into the limestone, a crib-bed was made at a depth of 354 feet 11½ inches, and a lift of tubbing inserted. No. 21 freezing-tube, *b*, was exposed at this crib-bed (Fig. 7, Plate XXVIII.). On October 10th, 1905, five trial-holes were bored through the rock and 7 feet into the sand, which was found to be frozen hard (Table V.).

Sinking was resumed and the sand was struck on October 31st, 1905.* Leading bore-holes were kept in advance while

* When this shaft had been sunk about 33 feet into the sand, a party of the members visited the colliery, and about 150 gentlemen descended the shaft to see the sinking in the frozen sand.

TABLE V.—SECTION OF STRATA SUNK THROUGH IN THE THERESA SHAFT, DAWDON COLLIERY.

No.	Description of Strata.	Thickness of Strata. Ft.	Ins.	Depth from Surface. Ft.	Ins.
	Alluvium—				
1	Soil	1	0	1	0
2	Clay	5	0	6	0
3	Gravel	3	0	9	0
	Magnesian Limestone—				
4	Marl, with hard limestone panels	6	1	15	1
5	Marl	22	6	37	7
6	Limestone	6	0	43	7
7	Strong bedded marl	66	0	109	7
8	Strong marl, in blocks	64	8	174	3
9	Hard limestone, honeycombed ...	60	6	234	9
10	Grey marl	4	7	239	4
11	Grey limestone	73	4	312	8
12	Grey limestone, with large gullets, filled with yellow limestone	23	4	336	0
13	Hard grey limestone	31	0	367	0
	Marl Slate— Ft. Ins.				
14	Soft shale ... 0 1				
15	Hard shale ... 1 3				
	——	1	4	368	4
16	Fish-bed	0	10½	369	2½
	Yellow Sand—				
17	Blue-grey sand ...	78	5	447	7½
18	Brown-grey sand ...	14	7½	462	3
	Coal-measures—				
19	Very hard post-girdle	1	1	463	4
20	Dark-grey shale, with red shale-bands	18	7	481	11
21	COAL	0	3	482	2
22	Grey shale	2	10	485	0
23	COAL	4	8	489	8
24	Grey post	1	9½	491	5½
25	Seggar-clay ...	10	7	502	0½
26	COAL	0	11½	503	0
27	Grey shale	6	0½	509	0½
28	Dark-grey shale ..	2	1	511	1½
29	COAL	0	3¼	511	4¾
30	Dark-grey shale ...	0	9¼	512	2
31	Grey post, with shale-partings ...	1	11	514	1
32	Very hard grey post	1	10	515	11
33	Grey post, with shale-partings ...	4	11	520	10
34	Dark-grey shale ...	1	2	522	0
35	Post-girdle ...	0	2	522	2
36	Dark-grey shale ..	0	10	523	0
37	Grey post	2	6	525	6
38	Grey shale	13	0	538	6
39	COAL	3	4	541	10
40	Seggar-clay ...	4	11	546	9
41	Grey shale	2	11	549	8
42	COAL	0	7	550	3
43	Seggar-clay ...	4	9	555	0

TABLE VI.—ACCOUNT OF THE CAST-IRON WEDGING-CRIBS IN THE THERESA SHAFT, DAWDON COLLIERY.

No. of Crib.	Description of Strata forming the Bed of the Crib.	Depth from Surface. Ft.	Ins.	Remarks.
1	Hard limestone, honeycombed ...	196	2	Water-feeders reduced from 6,075 to 1,100 gallons per minute.
2	Hard limestone, honeycombed ...	226	9	Water-feeders reduced from 2,850 to 1,470 gallons per minute.
3	Grey marl	236	5	Water-feeders reduced from 1,560 to 400 gallons per minute.
4	Grey limestone, with large gullets, filled with yellow limestone	327	11	Water-feeders reduced from 1,720 to 380 gallons per minute.
5	Hard grey limestone, frozen ...	354	11½	Frozen ground.
6	Blue-grey sand, frozen	390	5½	Do.
7	Blue-grey sand, frozen	431	5½	Do.
8	Dark-grey shale, with red shale-bands, frozen	468	7	Do.
9	Grey shale	508	4	—
10 and 11	Grey shale	530	9	Double wedging-crib.

sinking through the sand. After 34 feet had been sunk in the sand, a crib-bed was made at a depth of 390 feet $5\frac{1}{2}$ inches in the frozen ground and a metal crib with a foundation-course, 15 inches wide, and tubbing, backed with concrete, to secure the top portion of the sand and fish-bed, was inserted. Sinking was again continued for 45 feet 3 inches in the frozen sand; a second crib-bed was laid at a depth of 431 feet $5\frac{1}{2}$ inches and a metal-crib with a foundation-course, 15 inches wide, and tubbing, backed with concrete, was inserted.

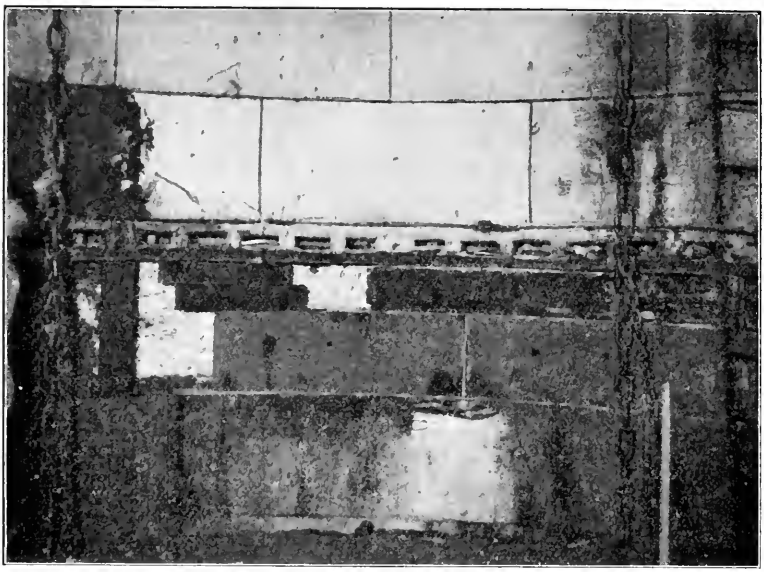


FIG. 41.—CRIB-BED AND TWO CLOSING-RINGS OF TUBBING IN FROZEN GROUND IN THE THERESA SHAFT.

The crib, in the Coal-measures to secure the sand, was laid at a depth of 468 feet 7 inches (Fig. 31, Plate XXXIV.). The crib and the closing rings of tubbing put in underneath it, are shewn in Fig. 41. The closing rings of tubbing were 16 inches and $8\frac{3}{4}$ inches high respectively. The crib below the frozen ground or ice-wall was laid at a depth of 508 feet 4 inches. The two bottom foundation-cribs, the lower one 18 inches wide and the upper one 22 inches wide, were laid at a depth of 530 feet 9 inches, and the tubbing was completed, the shaft at that time being 548 feet 4 inches deep.

(*f*).—*The Thawing of the Frozen Ground.*

One of the refrigerator-tanks was disconnected from the ammonia-circuit, in order that it might be used to thaw the frozen ground, to allow of the withdrawal of the tubes, and to allow of the pressure of water coming gradually upon the tubbing. A steam-pipe was connected to the spiral tube, and a circulating pump was coupled to the tank and to the collectors of the freezing-tubes at the shaft. The tank was then filled with brine, and steam was passed through the spiral tubes, warming the brine which was circulated by the pump through the tubes in the shaft.

Castlereagh Shaft.—The temperature of the brine, −18° Cent. (−0·4° Fahr.), left in the freezing-tubes at the end of the freezing of this shaft on October 19th, 1905, was found, on November 6th, 1905, to have risen to 0° Cent. (32° Fahr.).

The circulation of warm brine was commenced on November 7th, 1905. The temperature of the brine going to and returning from the shafts is recorded in Table VII.

TABLE VII.—TEMPERATURES OF THE BRINE EMPLOYED IN THAWING THE ICE-WALL AT THE CASTLEREAGH SHAFT.

	Temperatures of Brine: Going to Shaft.		Returning from Shaft.	
	Degrees Cent.	Degrees Fahr.	Degrees Cent.	Degrees Fahr.
1905.				
Nov. 9	5	41·0	0	32·0
,, 20	28	82·4	20	68·0
,, 23	31	87·8	22	71·6
,, 29	17	62·6	13	55·4
Dec. 4	20	68·0	17	62·6
,, 8	21	69·8	18	64·4

On November 26th, 1905, 19 days after beginning to thaw the ice-wall, a pressure of water was found to exist behind the tubbing, and a plug was blown out of one of the segments, 255 feet below the surface.

A large coke-fire lamp or brazier was suspended by chains to the sinking rope, on December 1st, 1905, and run slowly up and down the shaft to heat the air and melt the ice on the top lengths of tubbing and on the brickwork near the surface.

Two pressure-gauges were fitted to the tubbing to record the pressure of water behind it: one, placed at a depth of 306

feet below the top of the tubbing, recorded a pressure of 130 pounds per square inch; and the other, at a depth of 360 feet, recorded a pressure of 160 pounds per square inch.

The circulation of warm brine was maintained until January 2nd, 1906.

Theresa Shaft.—The same system of thawing was used in the Theresa Shaft as that used at the Castlereagh shaft. Warm brine was circulated from February 28th to May 4th, 1906.

Three holes were drilled, with an auger, $\frac{3}{8}$ inch in diameter, through the sheeting below each of the cribs of the tubbing, in both shafts, to be used for ascertaining what was taking place behind the tubbing during the thawing of the ice-wall. These holes acted as vent-holes both for air and water as the ice-wall thawed and prevented any "air-lock" from taking place. Water was allowed to run from them until the ice-wall was thoroughly thawed, and they were then wedged tight.

(g).—Removal of the Freezing-tubes.

Castlereagh Shaft.—The drawing of the tubes from the Castlereagh shaft was commenced on February 21st, 1906. The central tube was taken out of each hole. The freezing-tubes were removed by means of a drawing tool, which was lowered into the tube, at the end of solid-steel rods, a pair of clamps was bolted round the rods, and an upward pressure was brought to bear on the clamps by means of two hydraulic jacks capable of developing a pressure of 400 atmospheres per square centimetre or 2,581 atmospheres per square inch. The greatest lifting pressure exerted at any hole was 210 atmospheres per square centimetre or 1,355 atmospheres per square inch; and after a tube had once been moved, as a rule, it could be withdrawn by the steam-winch or hand-blocks provided for that purpose.

TABLE VIII.—LENGTHS OF FREEZING-TUBES LOST.

No. of Bore-hole.	Lengths. Metres.	Feet
3	39·56	129·79
5	33·79	110·86
6	45·40	148·95
15	40·35	132·38
17	116·76	383·08
18	30·06	98·62
27	31·33	102·79
28	39·00	127·96

Table VIII. records the lengths of freezing-tubes that were lost in the respective holes.

The withdrawal of the freezing-tubes at the Castlereagh shaft was finished on April 17th, 1906, 8 weeks from the commencement.

Theresa Shaft.—On May 2nd, 1906, the withdrawal of the central and freezing-tubes was commenced, and the whole of the tubes were withdrawn, none being lost, on May 25th, 1906, 3 weeks and 2 days from starting.

The bore-holes at each shaft were filled with gravel and sand, after the tubes were extracted, the upper portion of the holes near the surface, in some cases, being filled with cement-concrete.

The writer is greatly indebted to Mr. V. W. Corbett, mining agent and director of the Londonderry Collieries, Limited, under whose management the works in connection with the Dawdon winning have been successfully carried out, for permission to publish the facts and information detailed in this paper.

Mr. T. E. Forster said that one point was very clearly brought out in Mr. Wood's paper, and it would probably explain what had happened in other sinkings, namely, the necessity of preventing any circulation of the water. The diagrams showing that, until a sufficient quantity of concrete was thrown into the pit, the circulation of the water could not be stopped, were very interesting. Probably, when sinkings had to be made by this process, it would be better that the freezing should be commenced from the top. He would like to ask whether there was any difficulty with the tubbing when the ground was thawed. He was under the impression that the tubbing used at Dawdon was that ordinarily used in the district, and was not fitted with flanges inside the pit and bolted together. He would like to know what thickness of concrete-backing had been used.

Mr. E. Seymour Wood said that no difficulty had been experienced with the tubbing, when the ice-wall was being thawed; the only thing that happened to it was the blowing out of one of

the plug-holes. The entire tubbing was backed with concrete, 4½ inches thick, through the whole depth of the Yellow Sand, up to the Magnesian Limestone.

Mr. Bennett H. Brough (London) noted with interest that the results of the author's experience proved that the plumbing of bore-holes was an absolutely untrustworthy method of determining the deviation from the vertical. Various ingenious devices had been described* for determining the deviation, by means of a magnetic needle enclosed in a glass-phial filled with a hot solution of gelatine, by etching glass with hydrofluoric acid, and by an electric recording apparatus. With an instrument of the last-named type, Mr. H. F. Marriott† had detected enormous bore-hole deviations at the Turf mines, Johannesburg. For surveys of bore-holes in connection with the freezing process of shaft-sinking, excellent results had been obtained with instruments of the stratameter class, in which a compass-needle and a plumb-bob were regulated by clockwork. The various instruments of that class were described in detail in a recently published work by Mr. F. Freise.‡

The President (Mr. J. H. Merivale), in proposing a vote of thanks to Mr. Wood for his paper, said that that gentleman and the owners of the colliery were to be congratulated on having completed their difficult, expensive and arduous sinking by the freezing system.

Mr. W. B. Wilson, jun., seconded the vote of thanks, which was cordially adopted.

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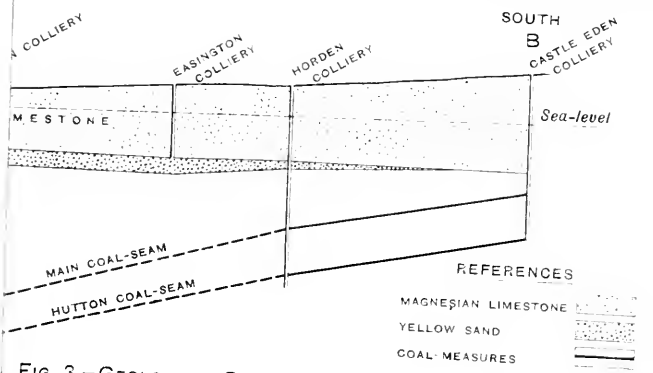
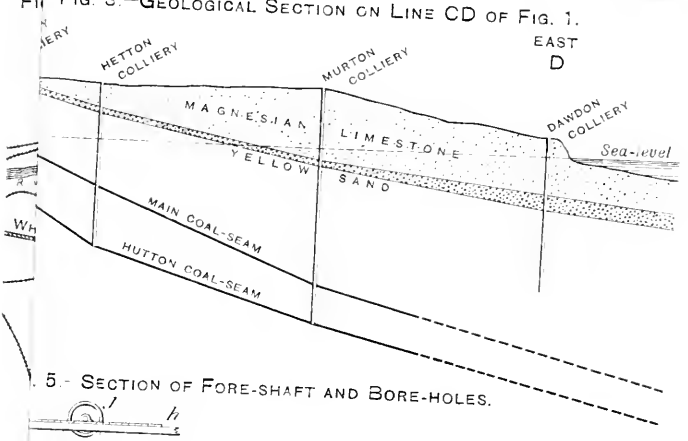
* *Treatise on Mine Surveying*; by Mr. B. H. Brough, twelfth edition, 1906, page 323.

† *Transactions of the Institution of Mining and Metallurgy*, 1905, vol. xiv., page 255.

‡ *Stratameter und Bohrlochneigungsmesser*, 1906.

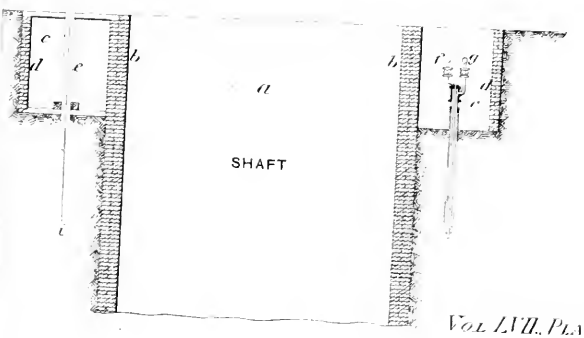


Fi Fig. 3.—Geological Section on Line CD of Fig. 1.



. 5.- Section of Fore-shaft and Bore-holes.

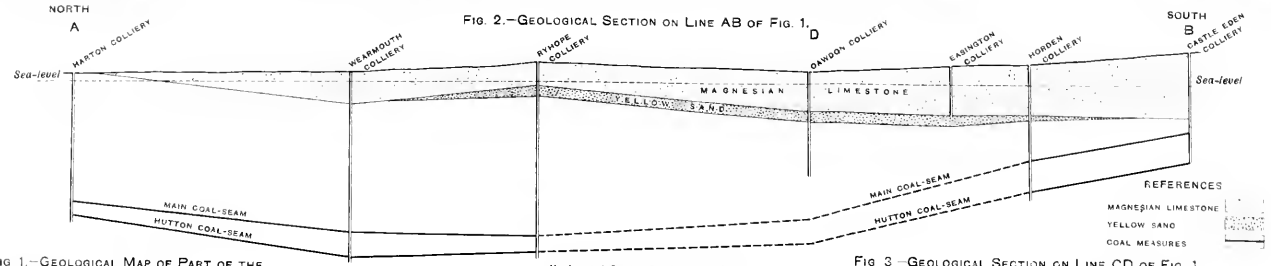
Scale, 15 Feet to 1 Inch.



The Institution of Mining Engineers
Transactions 1906-1907

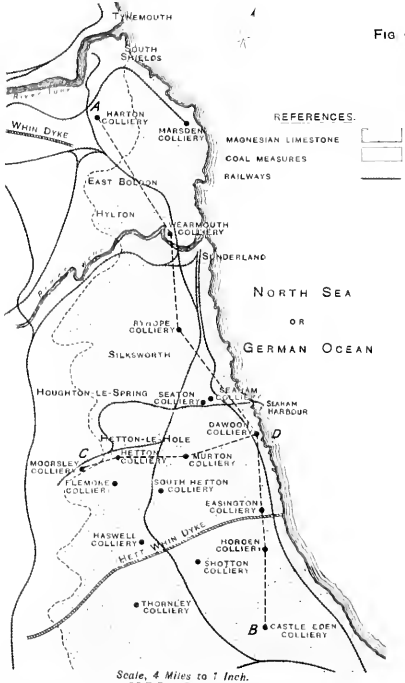
To illustrate Mr E.S. Woods Paper on "Sinking through Magnesian Limestone," etc

FIG. 2.—GEOLOGICAL SECTION ON LINE AB OF FIG. 1.



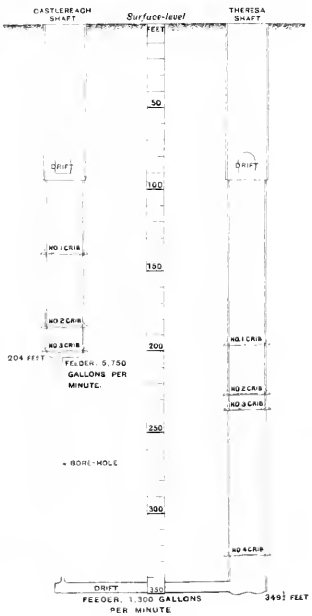
Horizontal Scale, 2 miles to 1 inch
Vertical Scale, 1,200 feet to 1 inch.

FIG 1.—GEOLOGICAL MAP OF PART OF THE COUNTY OF DURHAM.



Scale, 4 Miles to 1 Inch.

FIG. 4.—SECTIONS OF CASTLEREAGH AND THERESA SHAFTS SUNK BY PUMPING SYSTEM.



Scale, 80 feet to 1 Inch.

FIG 3.—GEOLOGICAL SECTION ON LINE CD OF FIG. 1.

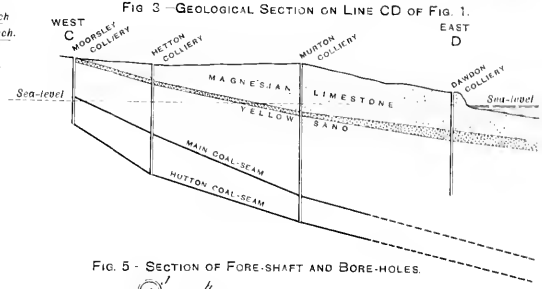
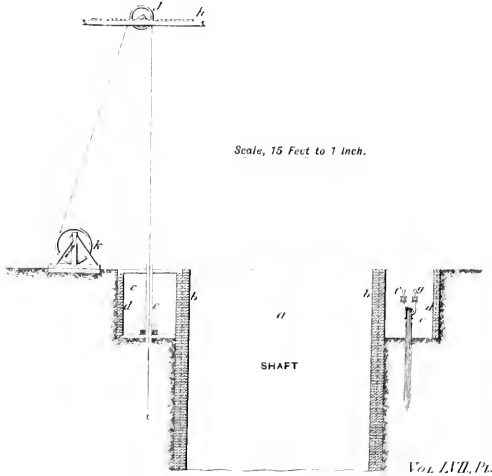


FIG. 5 - SECTION OF FORE-SHAFT AND BORE-HOLES.



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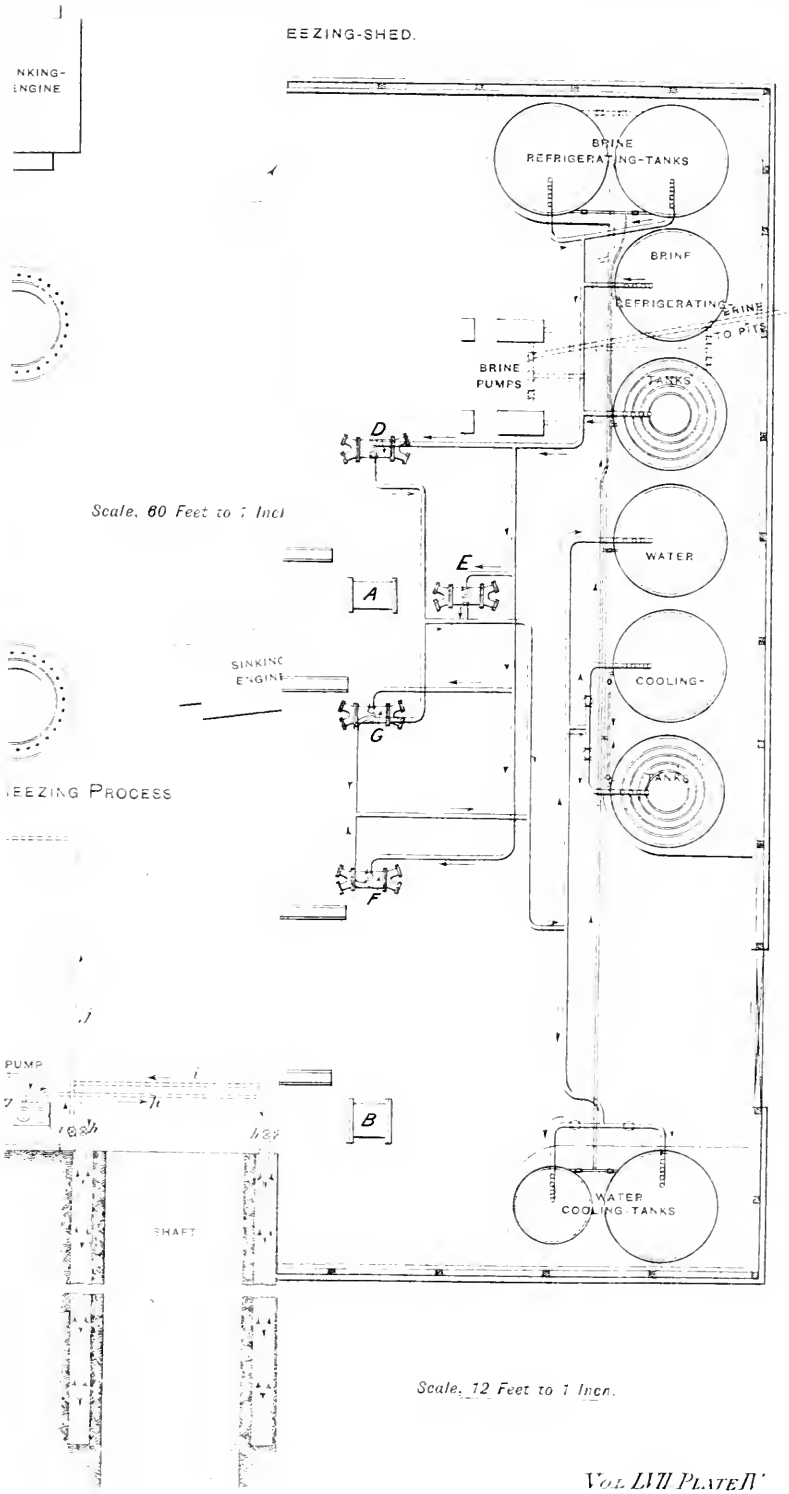

EEZING-SHED.
NKING-
ENGINE
BRINE
REFRIGERATING-TANKS
BRINE
REFRIGERATING-
BRINE
TO PIT
BRINE
PUMPS
TANKS
D
Scale, 60 Feet to 1 Inch
E
A
WATER
SINKING
ENGINE
COOLING-
G
EEZING PROCESS
F
PUMP
B
SHAFT
WATER
COOLING TANKS
Scale, 12 Feet to 1 Inch.

FIG 6.—PLAN OF BORE-HOLES AT CASTLEREAGH SHAFT

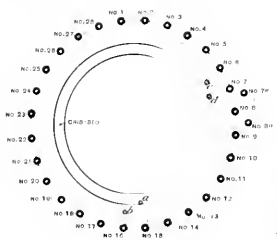
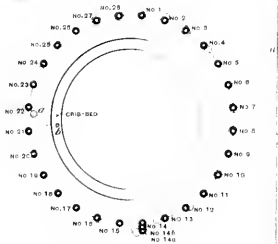


FIG 7.—PLAN OF BORE-HOLES AT THERESA SHAFT



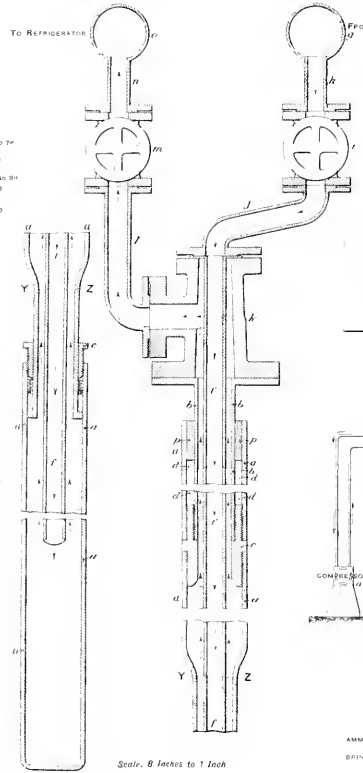
REFERENCES

TOP OF BORE-HOLE

BOTTOM OF BORE-HOLE

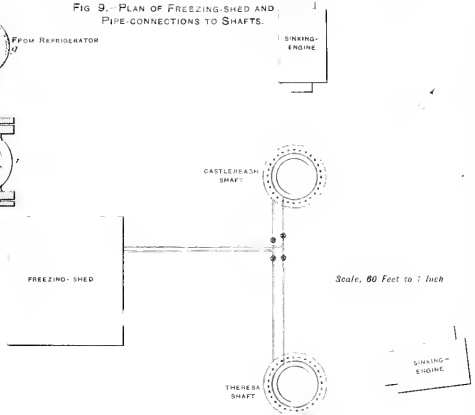
Scale, 15 Feet to 1 Inch

FIG 8.—SECTION OF A FREEZING TUBE



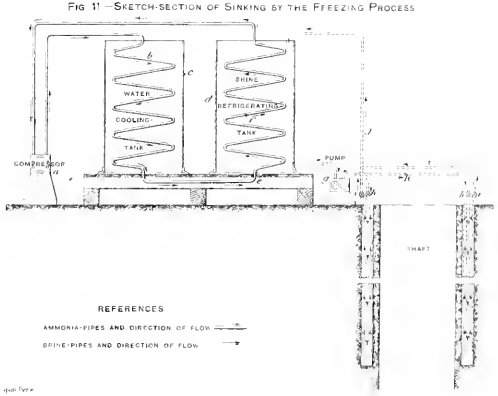
Scale, 6 Inches to 1 Inch

FIG 9.—PLAN OF FREEZING-SHED AND PIPE-CONNECTIONS TO SHAFTS.



Scale, 60 Feet to 1 Inch

FIG 11.—SKETCH-SECTION OF SINKING BY THE FREEZING PROCESS

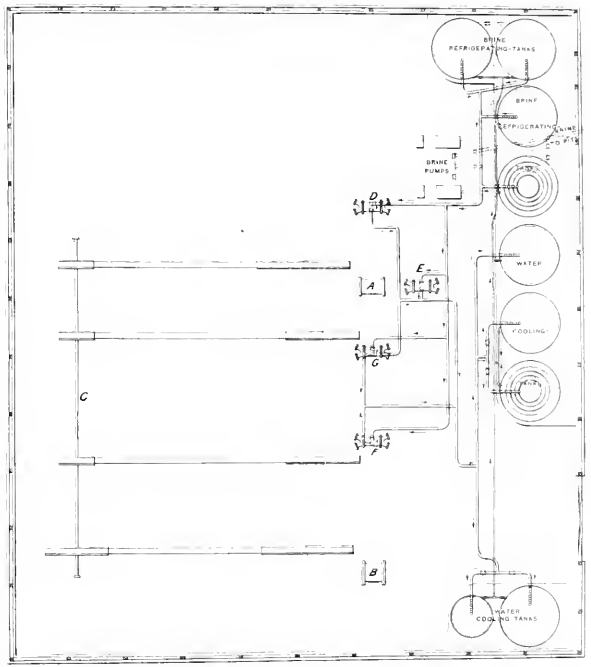


REFERENCES

AMMONIA-PIPES AND DIRECTION OF FLOW

BRINE-PIPES AND DIRECTION OF FLOW

FIG 10.—PLAN OF FREEZING-SHED



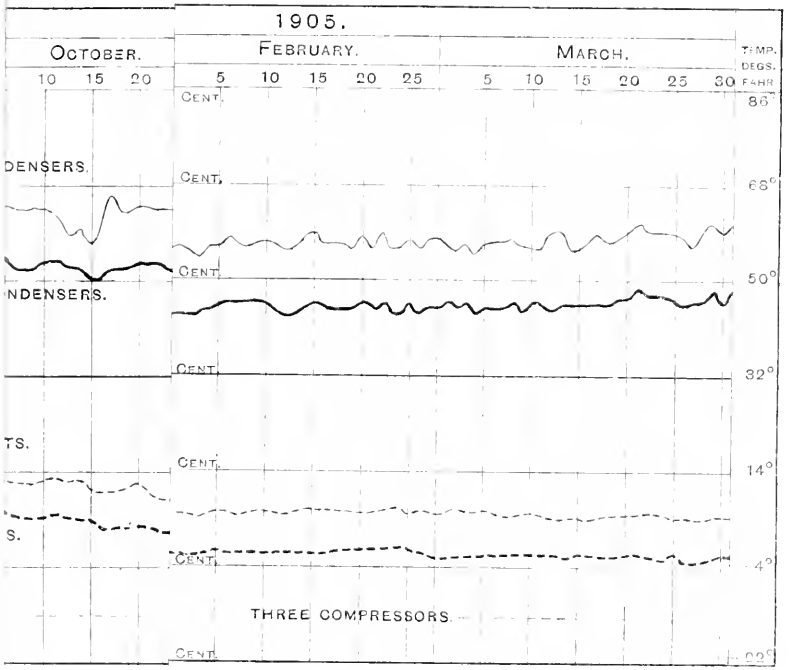
REFERENCES

AMMONIA-PIPES AND DIRECTION OF FLOW

BRINE-PIPES AND DIRECTION OF FLOW

Scale, 12 Feet to 1 Inch

ATURES OF BRINE



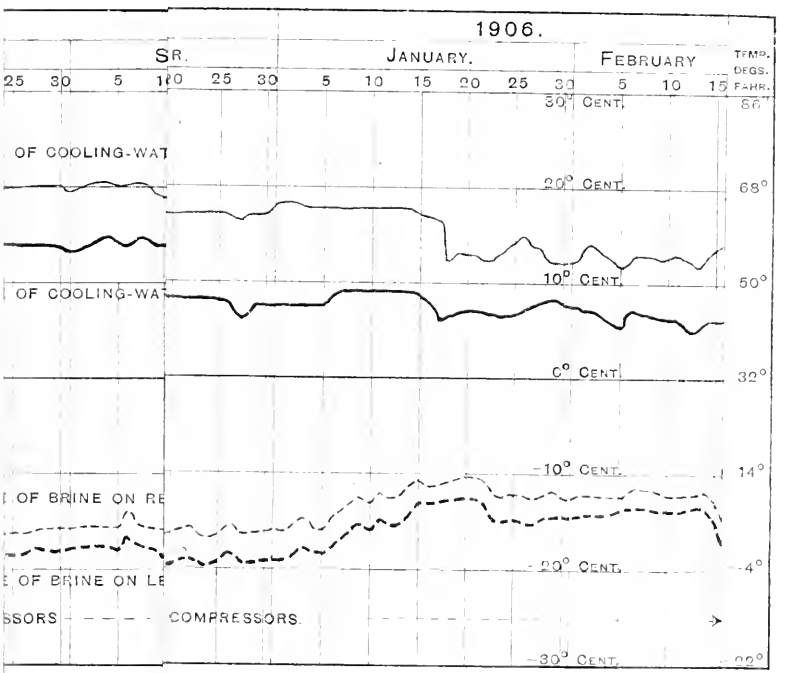
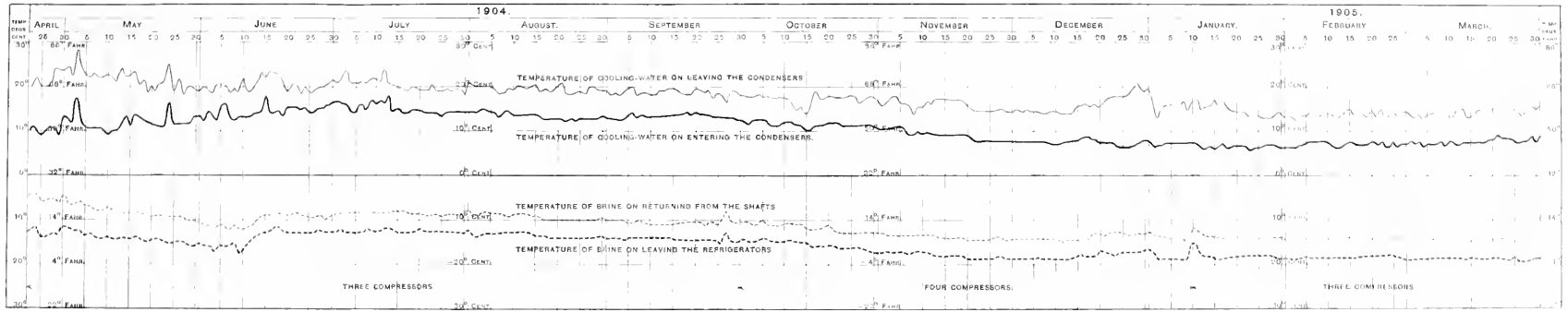
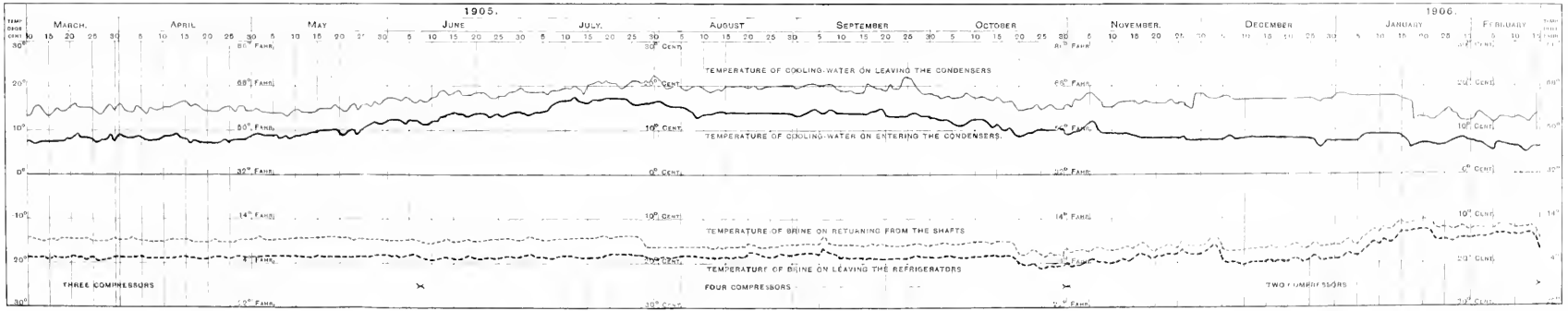
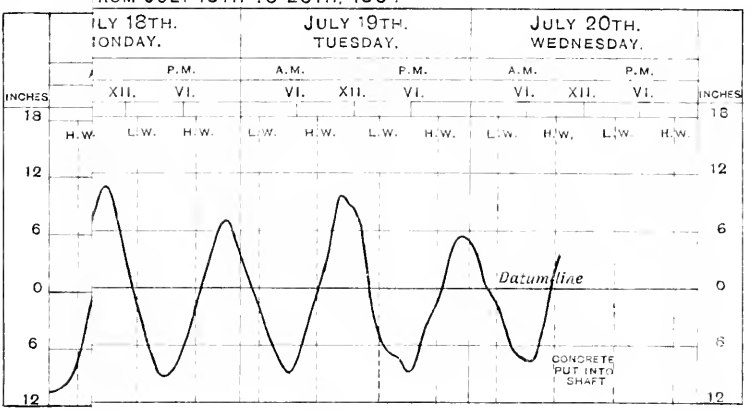


FIG 12.—CHART OF TEMPERATURES OF BRINE AND COOLING-WATER



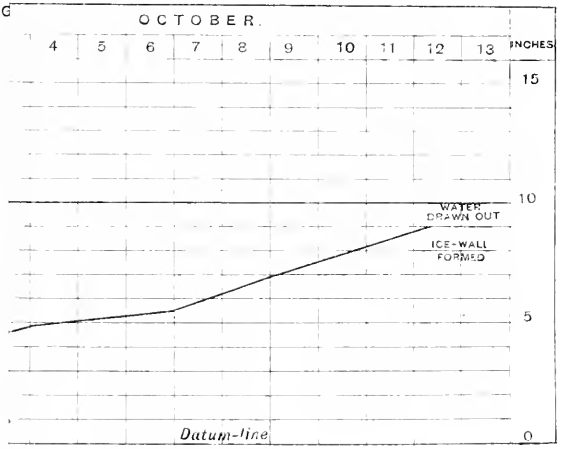


Trans FROM JULY 13TH TO 20TH, 1904.



VATER DUE TO THE FORMATION OF THE ICE-WALL
ER 22ND TO OCTOBER 12TH, 1904.

FIG



LY 13TH TO JULY 20TH, 1904.

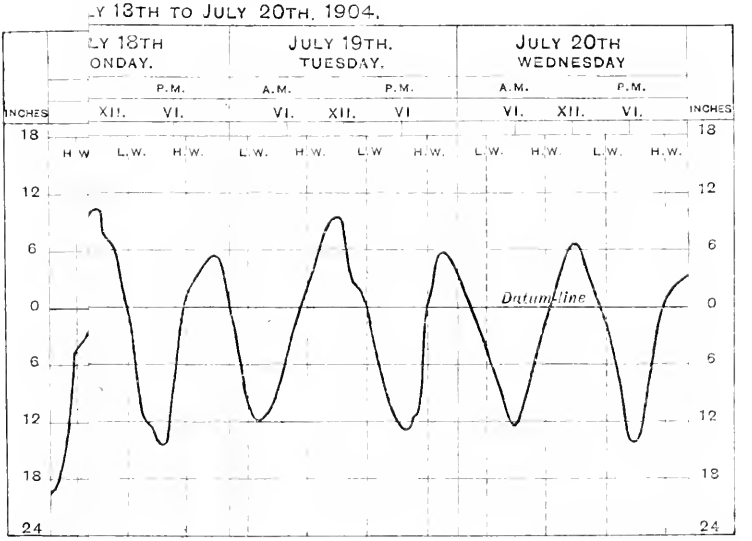


FIG. 13.—DIAGRAM SHOWING THE RISE AND FALL OF THE WATER IN THE CASTLEREAGH SHAFT, FROM JULY 13TH TO 20TH, 1904.

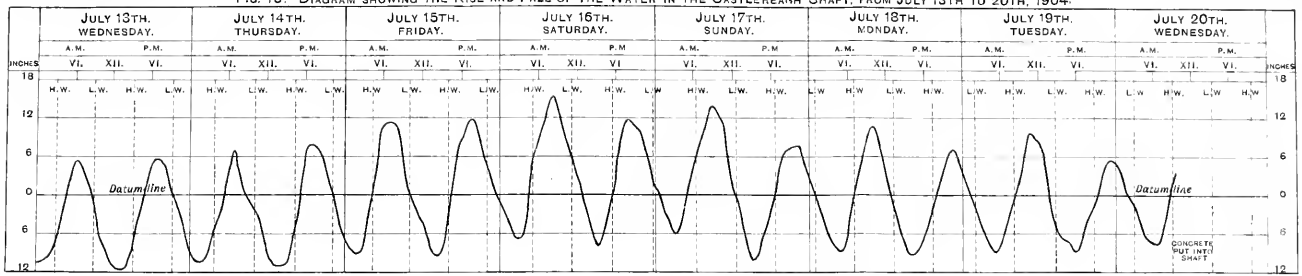


FIG. 14.- SECTION SHOWING CONCRETE IN CASTLEREAGH SHAFT.

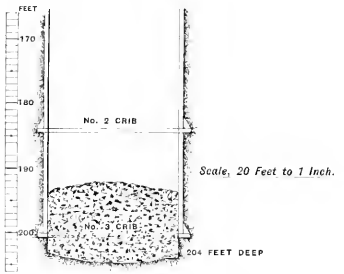


FIG. 15.—DIAGRAM SHOWING THE EXPANSION OF THE WATER DUE TO THE FORMATION OF THE ICE-WALL IN THE CASTLEREAGH SHAFT, SEPTEMBER 22ND TO OCTOBER 12TH, 1904.

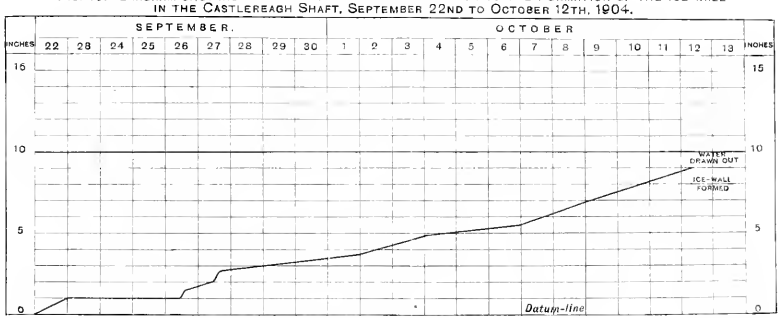
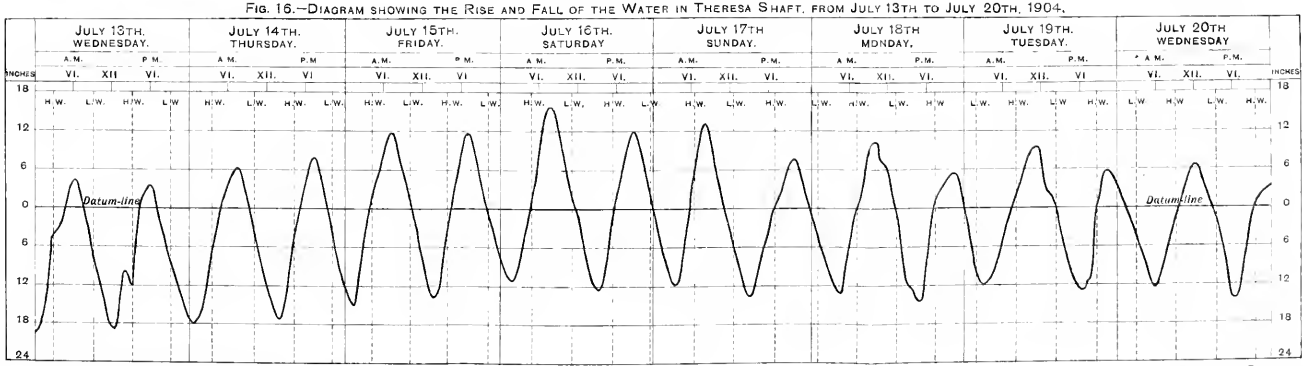


FIG. 16.—DIAGRAM SHOWING THE RISE AND FALL OF THE WATER IN THERESA SHAFT, FROM JULY 13TH TO JULY 20TH, 1904.



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OBER 31st, TO DECEMBER 2nd, 1904.

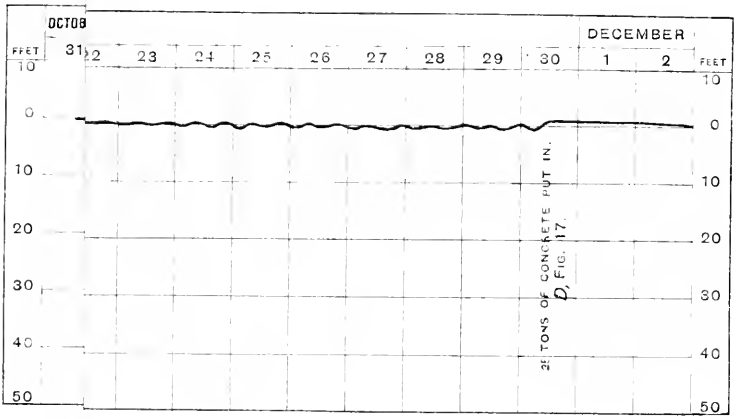


Fig. 17.

CON E ICE-WALL FROM JANUARY 18th TO MARCH 4th, 1905.

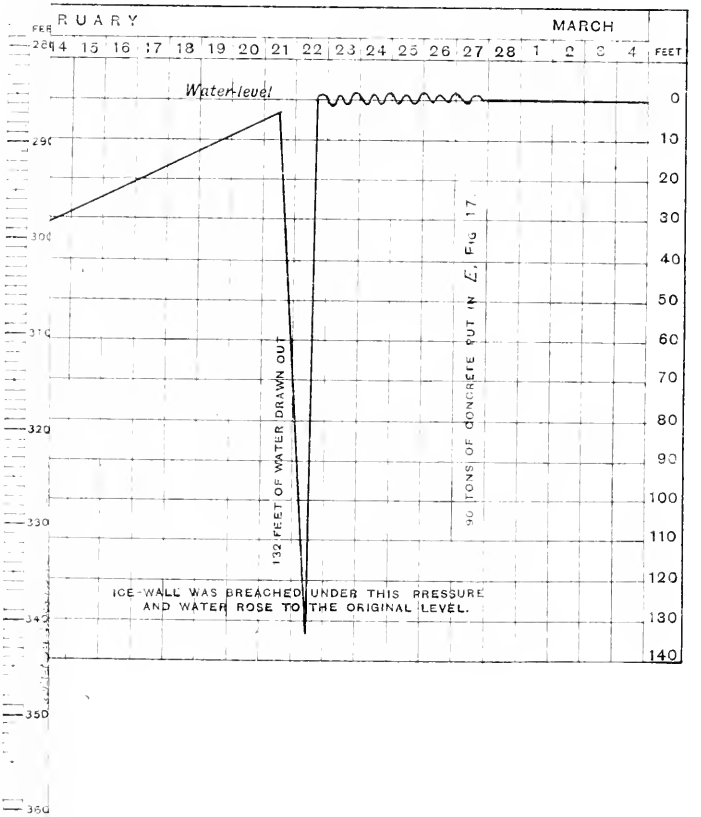


Fig. 18.—Diagram showing the Water-level in Theresa Shaft on Testing the Ice Wall from October 31st. to December 2nd, 1904.

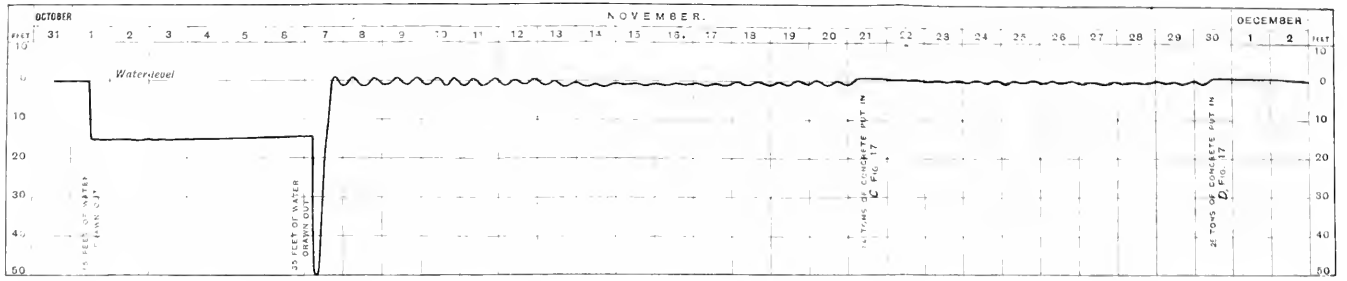


Fig. 17.—Section showing Debris and Concrete in Theresa Shaft

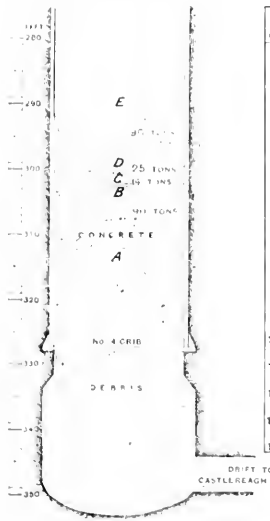
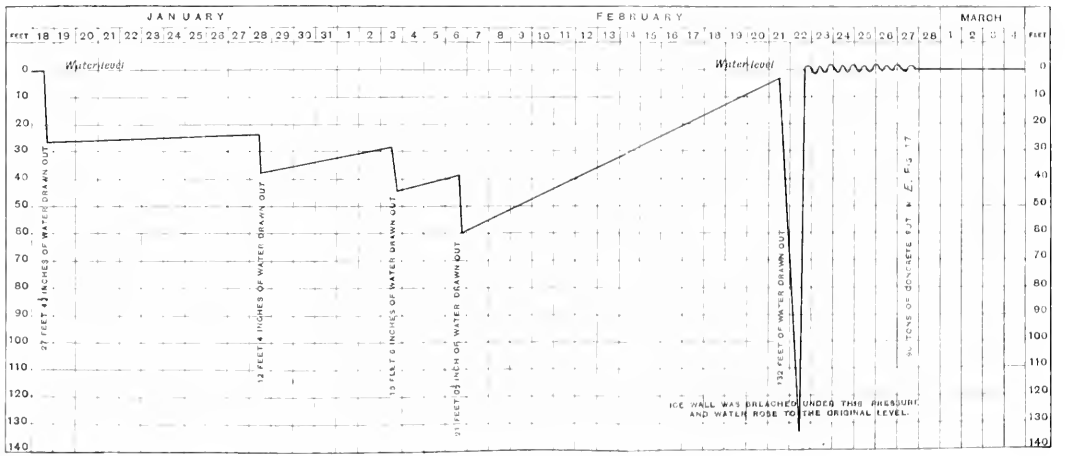


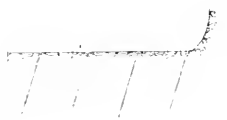
Fig. 19.—Diagram showing the Water-level in Theresa Shaft on Testing the Ice-wall from January 18th to March 4th, 1905



FPosition of Shot-holes
ıdugh Frozen Ground.

t to 1 inch.

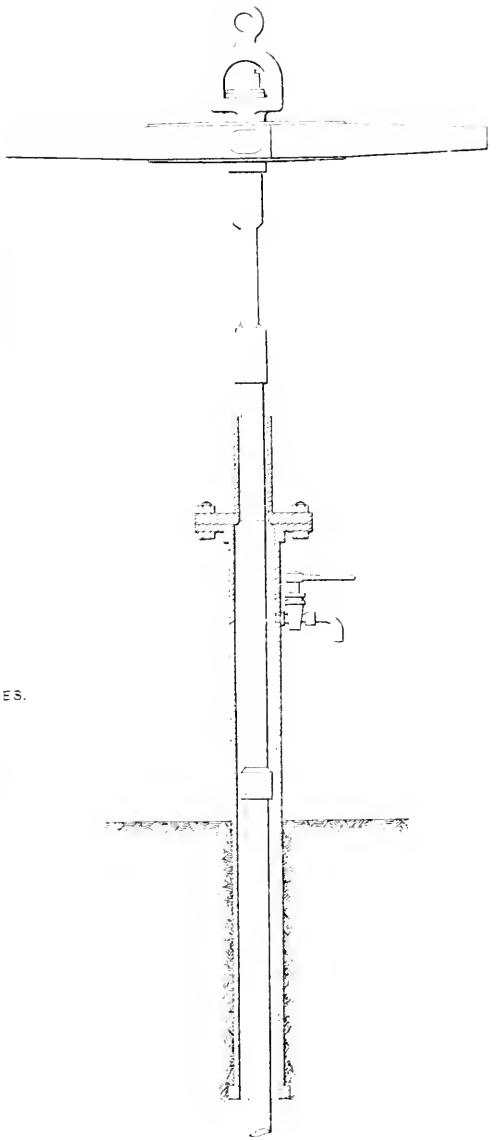
g Angles of Shot-holes.



t to 1 inch.

Ice-ring, at a Depth
Castlereagh Shaft,
ry 8th, 1906.

Fig 26.—Elevation of Stuffing-box
for Boring against Water



Scale, 1 Foot to 1 Inch.

Fig. 20.—Section of Ice-wall on Tubbing in Theresa Shaft, on August 12th, 1905.

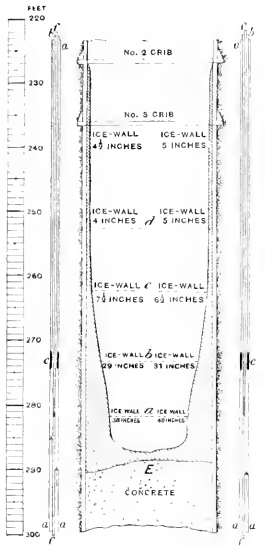
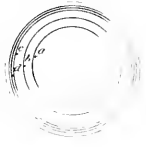


Fig. 21.—Plan of Ice-wall on Tubbing at Increasing Depths in Theresa Shaft.



Scale, 20 Feet to 1 Inch.

Fig. 22.—Elevation of Ice-wall on Tubbing in Theresa Shaft, on February 22nd, 1905.

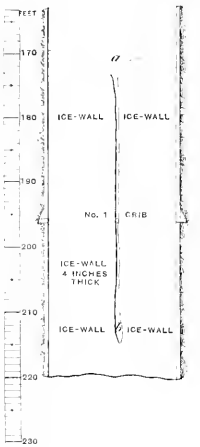
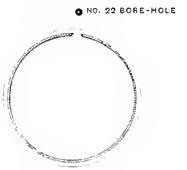
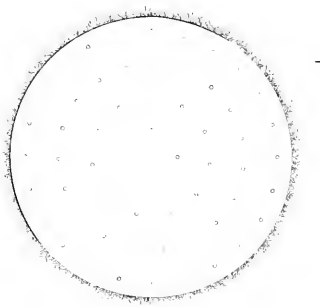


Fig. 23.—Plan of Ice-wall on Tubbing in Theresa Shaft



Scale, 20 Feet to 1 Inch.

Fig. 24.—Plan showing Position of Shot-holes when Sinking through Frozen Ground

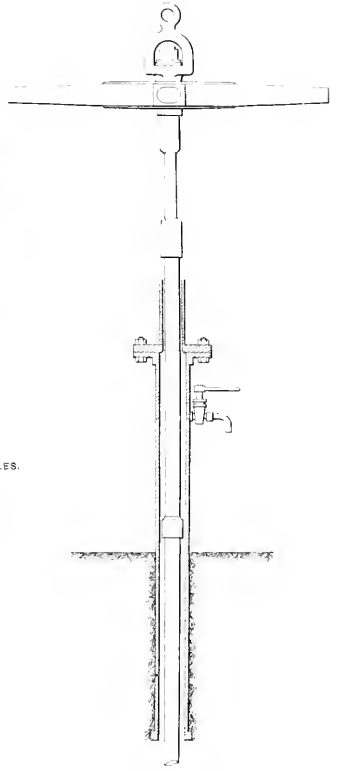


Scale, 10 Feet to 1 Inch.

Fig. 25.—Section showing Angles of Shot-holes.

Scale, 10 Feet to 1 Inch.

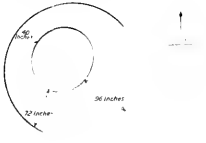
Fig. 26.—Elevation of Stuffing-box for Boring against Water



Scale, 1 Foot to 1 Inch.

Fig. 27.—Plan of Ice-ring at a Depth of 239 Feet in Castlereagh Shaft, on December 9th, 1905

Fig. 28.—Plan of Ice-ring, at a Depth of 260 Feet in Castlereagh Shaft, on January 8th, 1906.

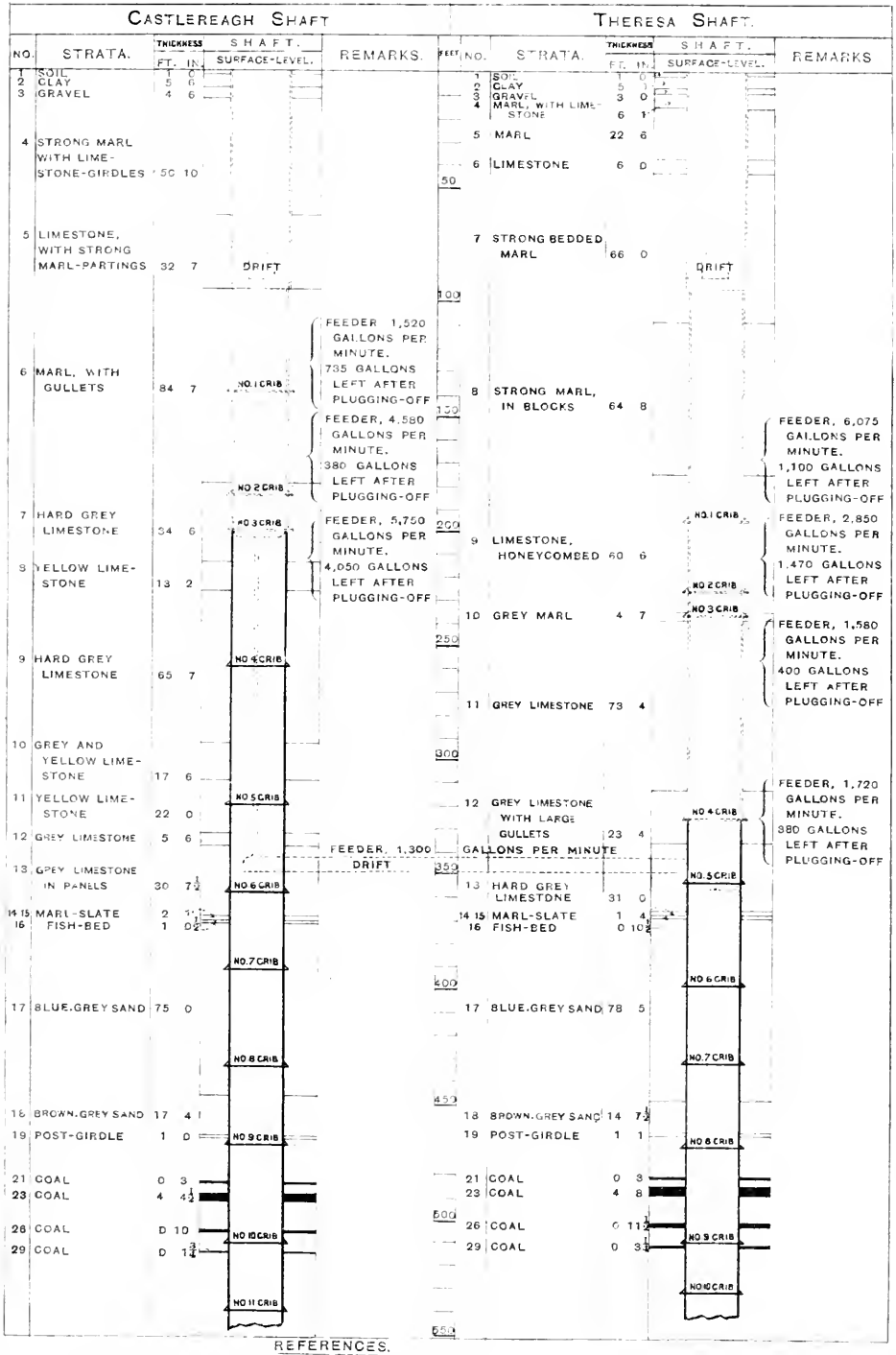


Scale, 20 Feet to 1 Inch.

The Institution of Mining Engineers
Transactions 1906/1907

To illustrate Mr E.S. Wood's Paper on "Sinking through Magnesian Limestone," etc

FIG. 31.—SECTIONS OF STRATA SUNK THROUGH IN CASTLEREAGH AND THERESA SHAFTS. BY PUMPING AND FREEZING SYSTEMS.



REFERENCES.

WORK DONE PREVIOUS TO ADOPTION OF FREEZING PROCESS IN 1903 ----------

WORK DONE BY FREEZING PROCESS

Scale. 80 Feet to 1 Inch.

The North of England Institute of Mining & Mechanical Engineers
Transactions, 1906/1907

And.w Reid & Comp.y Ltd. Newcastle upon Tyne

Fig. 29.—Diagram showing Losses of Temperature of Brine returning from Bore-holes in Theresa Shaft, on February 19th and 23rd, 1905.
The Brine supplied to the Bore-holes had Temperatures of −2° and −1·8° Fahr., or −18·9° and −18·8° Cent. on each date respectively.

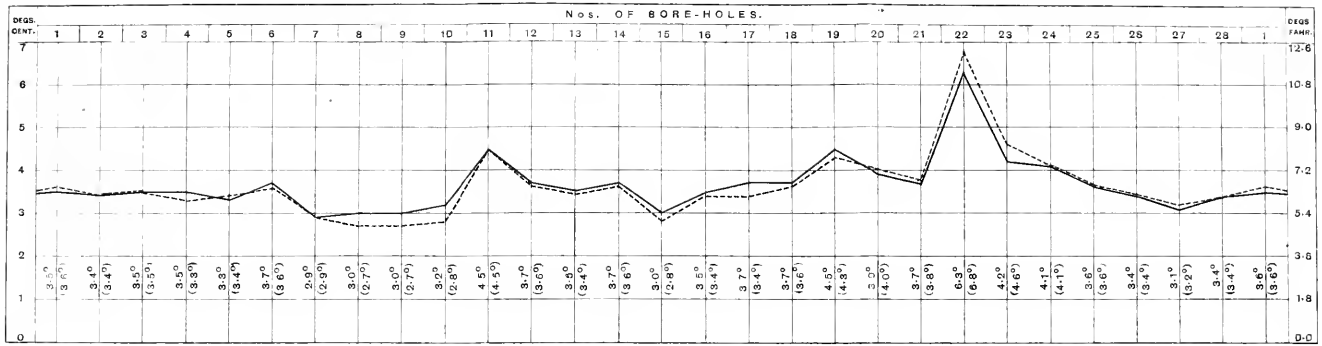
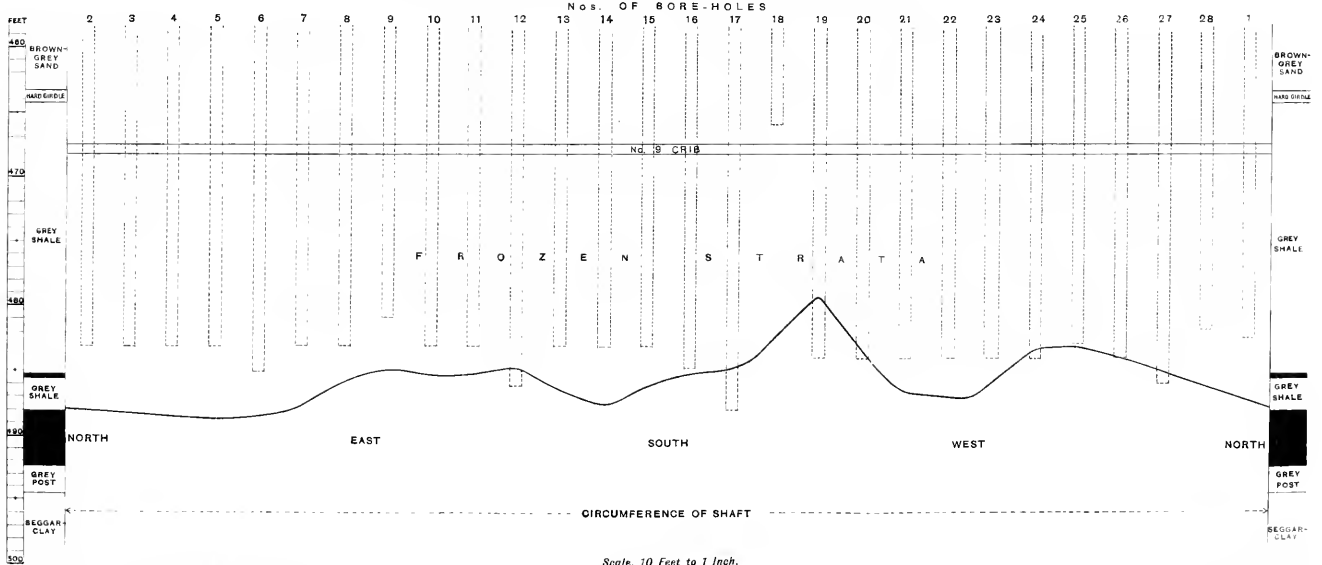


Fig. 30.—Diagram showing the Finish of Frozen Ground in Castlereagh Shaft.



Scale, 10 Feet to 1 Inch.

The North of England Institute of Mining & Mechanical Engineers
Transactions 1906 1907

Andw Reid & Compy Ltd Newcastle upon Tyne

Vol. LVII, Plate IX

THE NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

GENERAL MEETING,
HELD IN THE WOOD MEMORIAL HALL, NEWCASTLE-UPON-TYNE,
FEBRUARY 9TH, 1907.

MR. J. H. MERIVALE, PRESIDENT, IN THE CHAIR.

The SECRETARY read the minutes of the last General Meeting and reported the proceedings of the Council at their meetings on January 26th and that day.

The following gentlemen were elected, having been previously nominated:—

MEMBERS—

Mr. ALEXANDER RICHARD BEKENN, Mine-manager, Dundee Coal Company, Limited, Talana, Natal, South Africa.

Mr. EVENCE COPPÉE, Civil Engineer and Managing Director of Collieries, Avenue Louise, 211, Brussels, Belgium.

Mr. ERNEST CHARLES DUNKERTON, Mechanical Engineer, 97, Holly Avenue, Newcastle-upon-Tyne.

Mr. JOHN THOMAS FOULIS, Mine-owner and Mine-manager, Durban House, Ramsey, S.O., Isle of Man.

Mr. FREDERICK JAMES RAINE, Colliery Manager, Etherley Grange Colliery, Bishop Auckland.

ASSOCIATE MEMBERS—

Mr. WILSON ORMROD, Union Buildings, St. John Street, Newcastle-upon-Tyne.

Mr. FREDERICK GEORGE WALEY, The Bellambi Coal Company, Limited, 9, Bridge Street, Sydney, New South Wales, Australia.

ASSOCIATE—

Mr. ALFRED HILL ASKEW, Under-manager, 16, Telford Street, Gateshead-upon-Tyne.

STUDENTS—

Mr. WILLIAM GRACE GRACE, Mining Student, Hall Garth Hall, Winlaton, Blaydon-upon-Tyne, S.O., County Durham.

Mr. HERBERT STANLEY HUNTER, Mining Student, Blakelaw, Kenton, Newcastle-upon-Tyne.

DISCUSSION OF MR. OTTO SIMONIS' PAPER ON "LIQUID AIR AND ITS USE IN RESCUE-APPARATUS."*

Mr. HENRY SIMONIS (London) exhibited the aerolith apparatus, and also made some interesting experiments. Liquid air was preferably stored in vessels designed by Sir James Dewar: these were practically vacuum vessels, but closed by a thick felt-cover through which it was possible for the air to penetrate to a small extent. In such a bottle, liquid air would keep for about 12 days: the evaporation not exceeding 6 per cent. per day. It was easy to transport, and if packed in a case could be forwarded ordinarily by railway, as there was no danger whatever of its exploding. A vessel containing $3\frac{1}{2}$ pints enabled the wearer of the aerolith apparatus to work for 60 to 70 minutes, and a large vessel holding 9 pints was sufficient for 3 hours' work. Liquid air was approximately of the same specific gravity as water, weighing about $62\frac{1}{2}$ pounds per cubic foot and 10 pounds per gallon, and therefore when filled with 9 pints for 3 hours' work, the apparatus (which weighed 14 pounds) would weigh 25 pounds. Liquid air cost about 6d. per gallon, when made with a small plant; and with a larger plant the cost would be considerably reduced. By the Claude system, it was calculated that one horsepower (suction-gas or any other cheap method of producing power being used) would produce 4 gallons of liquid air at a cost of $1\frac{1}{2}$d. per gallon.

Mr. A. L. STEAVENSON (Durham) said that no one had a greater admiration than himself for the skill and knowledge which had been employed to perfect life-saving apparatus during the last 50 years; and yet, at the present day, Mr. G. A. Meyer stated that "it was difficult to understand why the Schwann apparatus had, for so many years, been entirely forgotten."† The Fleuss apparatus, and many others, one after another, had all

* *Trans. Inst. M. E.*, 1906, vol. xxxii., page .

† *Ibid.*, vol. xxxi., page 579.

come and gone, because they were found to be of no practical use. At a time when apparatus of this kind was called into requisition, it was necessary for the wearer to scramble over difficult falls and sometimes to squeeze through very small passages, then a man found that his ordinary pit-clothes were an encumbrance: and it was as much as he could do to trail himself through, without having an apparatus to carry on his back. In 1854, Mr. T. Y. Hall, a good practical pitman, brought the subject of rescue-work before the members, and recommended the use of pipes carried along the main roads; and he (Mr. Steavenson) told them to-day that this was the best suggestion that had been made during those 53 years.* In many mines compressed air was being used, and he (Mr. Steavenson) suggested that the pipes should be carried along the main roads and fitted with cocks, so as to give off the air necessary to help any persons shut off. In most cases the members were told that 2 or 3 hours was the utmost limit of time for working a modern rescue-appliance, but Mr. A. M. Henshaw, a thoroughly practical man, had stated that in 37 minutes confusion of mind occurred in the case of a man, who was 200 feet away from everybody else;† he began to lose confidence and would throw off the apparatus, and it was owing to this cause that a man, wearing a rescue-apparatus, was killed at the Courrières mines.‡ The rescuers in that disaster did not save any lives, but they lost one, because the wearer of the apparatus had lost confidence in it. Dr. J. S. Haldane and Mr. Bennett H. Brough approved of the use of rescue-apparatus;§ but they were not practical pitmen, and did not know what it was to travel a fallen road filled with irrespirable air. Mr. W. E. Garforth stated that "considering the interval [60 years] that has elapsed since the first efforts were made, it is disappointing to have to admit that there is not, at the present time, a rescue-apparatus which can be fully relied upon,"‖ and he (Mr. Steavenson) agreed with that conclusion. Mr. Garforth had erected an experimental gallery to test the different forms of rescue-apparatus,¶ but

* *Trans. N. E. Inst.*, 1854, vol. ii., page 87.

† *Trans. Inst. M. E.*, 1906, vol. xxxi., page 615.

‡ *Ibid.*, vol. xxxi., page 610.

§ *Ibid.*, vol. xxxi., page 617. ‖ *Ibid.*, vol. xxxi., page 628.

¶ "Experimental Gallery for Testing Life-saving Apparatus," by Mr. W. E. Garforth, *Trans. Inst. M. E.*, 1901, vol. xxii., page 169.

that was not sufficient. The man who submitted to experiment in such a gallery knew that he could get out of it in 10 seconds, and would not, therefore, lose his confidence in an appliance. Supposing, in a case like the Courrières mines, that the rescue-party got in after much trouble, and that there was, say, a length of 1,500 feet, where there was good air, and then a noxious zone of 1,500 feet: after getting through that, what good purpose could a man wearing a rescue-apparatus fulfil? If he did find a number of men he would be quite unable to bring them through that zone of 1,500 feet of noxious gases. The rescue-party could never do any good work, unless by some means they carried fresh air with them. At the Courrières collieries nothing was accomplished beyond bringing out a number of dead bodies, and no good purpose was served by that. The best plan was to carry the fresh air in with them, and it was the only plan that held its own to-day. The members were much indebted to Messrs. W. N. and J. B. Atkinson for the time and trouble which they had devoted to the question of the prevention of coal-dust explosions. There was no reason why the roads of a mine should not be kept perfectly clean; let them provide sprinkling or spraying apparatus if desired, but certainly let the dust be kept out. As another way of preventing the devastation which takes place, he would advocate that the stoppings be bowed slightly outward, so that they could not be shifted or injured by an explosion; and then they would have a permanent road which no explosion could destroy, and which would enable them to penetrate into a mine whenever it became necessary to do so.

Prof. Henry Louis (Armstrong College) asked whether the apparatus described by Mr. Simonis had ever been tested, so as to ascertain that one gallon of liquid air would actually keep a man supplied with fresh air for 3 hours: this was about 40 cubic feet of air per hour, which was a somewhat small allowance, unless the man got some external air. Tested in the air of an ordinary room, which was drawn back and was available for breathing, this quantity of air might be satisfactory; but, if the apparatus was used in an irrespirable atmosphere, it might easily be too small. It would be interesting, therefore, to know whether any practical tests had been made on this point. He was not at all sure that the differential evaporation, as between

nitrogen and oxygen, which was claimed as an advantage for liquid air, was not rather a disadvantage, as a human being was not constructed so that he could breathe, without discomfort, practically pure nitrogen or oxygen. He also had his doubts as to any benefit that might result from the reserve air-bag, which would become distended with the air which had been breathed by the wearer, and which was (as a last resource in the event of the supply of liquid air running out) to be breathed again, at a time when the man would be fagged and worn out, and, therefore, in special need of fresh air.

Mr. T. E. Forster (Newcastle-upon-Tyne) said that he supported, in a great measure, Mr. Steavenson's views. Rescue-apparatus must be used with a great deal of care and caution. Where a pit had to be reopened after an explosion, the air must be systematically taken in by the explorers. The only use which he saw for the apparatus was in the case where men were overcome with gas in places which could be easily reached; and he knew of an instance, recently, where an appliance of this kind might have saved the lives of two men. The apparatus would also be useful to make explorations in advance of the air, so as to see the direction in which to open out most easily.

Mr. C. C. Leach (Seghill) said that the apparatus would frequently get out of order, and a possible danger would arise, as nobody would know exactly whether it was ready for use, for these appliances were not used everyday.

Dr. Thomas Oliver (Newcastle-upon-Tyne) said that the subject was one in regard to which he could only offer a few remarks of a purely academic character, as he had had no experience whatever of the practical use of rescue-appliances such as were before the members to-day. Still, he was one of those who thought that they should not strike altogether a despondent note. He quite agreed with Mr. Steavenson, if they could carry air into the pits as far as they possibly could, that this was the right thing to do. Experience had already shown the value attached to such apparatus in the case of fire, etc., and he thought that the time had come—for the Courrières explosion had awakened a spirit of public enterprise in the matter, and legislation had already done much for the safety of the men while working—when something would have to be done by science in

regard to the saving of life after explosions. Small quantities of carbon monoxide were sufficient to bring about headache and dizziness, followed in a short time by loss of power in the limbs, which prevented the miner, though most wishful to escape, from getting away, for he would soon fall and die. Mr. Steavenson had alluded to the presence of dead bodies in the pit, and he (Dr. Oliver) thought it was only right to say that there was nothing that proved such a source of discomfort and danger as the large number of bodies in the Courrières mine, all of which were undergoing extremely rapid putrefaction. Whether bodies were left in the pit or not, was a question which would have to be solved by mining engineers themselves. There was certainly the danger that a rescue-apparatus might not work at the proper time; but, without committing himself to an opinion on that matter, the time had come when they were almost obliged to face the question, and see whether something could not be done in the way of using rescue-apparatus. It was perfectly clear that men could not under ordinary circumstances go into parts of the mine where carbon monoxide was; but if by such appliances as these they could go in and stay 1 hour, or longer, and if it could be shown that they could travel through the difficult places mentioned by Mr. Steavenson, a great deal would have been accomplished. He (Dr. Oliver) would not discourage the use of scientific appliances of this kind, but would rather encourage them, and therefore good service had been done by Mr. H. Simonis in coming to explain this apparatus that day. There was not the least doubt that, after explosions, carbon monoxide was the cause of the death of miners. The largest number of men who died in the Courrières mine died from that cause, and very few from shock and burns. It was an interesting point, and he had found the same thing in experiments on animals, that many of the miners died from pneumonia after being rescued. In the case of animals that had not been killed by carbon monoxide, a few days afterwards they died from pneumonia, and, on microscopical examination of the lungs he had found small hæmorrhages in the air-cells of the lungs. If this rescue-work was to be encouraged, he (Dr. Oliver) thought that they should follow Mr. W. E. Garforth's suggestion that training galleries should be erected where men might be put through the same trials as those that they would have to undergo in the mine after an explosion; and, if they could stay in the pit under these

conditions for 2 or 3 hours, he was of the opinion that the value of the apparatus would be quite substantiated.

He (Dr. Oliver) thought that other important facts would come out soon in regard to carbon monoxide. If they were going to train men for rescue-work, there was something in overcoming the initial nervousness alluded to: therefore, men who had been trained were much more likely to go into the pit, knowing how far the apparatus could be relied upon. Perhaps, too, they could be trained to the inhalation, within limits, of carbon monoxide. It was a well-known fact that animals could be exposed to air containing carbon monoxide to the extent of causing 25 per cent. of saturation of the colouring matter of their blood, that is to say, to cutting off one-quarter of the respiratory power, and with the remaining three-quarters they got on very well. With carbon monoxide there was at first a certain amount of blood-destruction, but the red blood-corpuscles subsequently became increased, and the respiratory power was quite sufficient to overcome the deficiency. These animals lived and had excellent health, they improved in weight, the blood improved in quality: and they could, by gradually increasing the percentage of carbon monoxide, carry it to 35, or even 45, per cent., and the animals would still live, while one which had not been so trained would die in a very short time if placed in such conditions. He therefore threw out the suggestion that, if Mr. Garforth's proposed galleries were erected and Messrs. Nasmith and Graham's experiments* were confirmed *re* carbon-monoxide poisoning, a gradual acclimatization of men to mixtures of carbon monoxide might be shown to be possible within certain limits, as in the case of animals.

Mr. C. C. Leach (Seghill) asked whether Dr. Oliver advocated that all who went down the mine should be taught to breathe an atmosphere containing a high percentage of carbon monoxide.

Dr. T. Oliver said that he had only stated what had been done with animals: he did not venture himself to suggest that the men should do so, but it was worth consideration. If men could become acclimatized to carbon monoxide, it would prove of great value, especially if a certain amount of fresh air, in cylinders, could be carried in by the rescue-party for the entombed miners.

* The Haematology of Carbon-monoxide Poisoning," by Mr. G. G. Nasmith and Mr. D. A. L. Graham, *Journal of Physiology*, 1906, vol. xxxv., page 32.

Mr. C. C. Leach remarked that they would probably want to send in only a few men, but how were the hundreds already in the mine to be saved?

Dr. T. Oliver said that fresh air or cylinders of oxygen should be carried in by the rescue-parties.

Mr. Henry Simonis, replying to the discussion, said that Mr. A. L. Steavenson's remarks were directed against all rescue-apparatus: but, after Dr. Oliver's remarks, he did not think that he need reply to him. The use of pipes was an old idea, and, only about a month ago, he discussed with Dr. J. S. Haldane the possibility of leading liquid air in pipes to be used in mines, and sprayed by sprinklers, as water was used in combatting a fire, that was to say, whether it would be possible, with certain appliances, to arrange that the liquid air should be automatically released, and the liquid air could then be poured into the pit so as to purify the air and produce a breathable atmosphere at the same time. He did not think that it would be possible to reduce the size and encumbrance of the aerolith apparatus below its present dimensions: it was certainly, by far, the lightest and most compact form that had yet been introduced. With regard to practical experience with the apparatus, a complete installation, at one of Baron Rothschild's collieries in Austria, had been working for about 3 months; and another similar plant had been erected and would be completed at another colliery within a few days. It had been proved thereby that 3 hours' work could very easily be performed with the apparatus, even allowing a wide margin, when charged with 1 gallon of liquid air, the equivalent of 120 cubic feet of breathable air, and this was more than sufficient for any man working for 3 hours. He (Mr. Simonis) did not put any stress on the reserve-bag; it was only the very last resource possible, and experiments had shewn that the air contained in this bag was still holding a larger percentage of oxygen than ordinary atmospheric air. There was no possibility of the apparatus going out of order, and as there was not a single valve nor complication of any kind, the apparatus was bound to work the moment that liquid air was poured in, although it might have been lying untouched for any length of time. It did not follow that pure oxygen would do a man any harm, because a man's lungs were so constructed that they could not take more than a certain amount

of oxygen, so that any excess would simply flow away with the air exhaled, and so do no harm whatever. Dr. Oliver's remarks about carbon monoxide were very interesting to him personally, and absolutely new: and he would try to get some men to try the suggested experiment. A plant capable of producing about 0·9 gallon of liquid air per hour would cost from £300 to £400, and it would require from 6 to 8 horsepower, so that according to the cost of the power, the cost of producing liquid air could be calculated. Under conditions, not at all favourable, the cost would not exceed 2s. 4d. per hour or 2s. 7d. per gallon.

Mr. T. C. Futers asked whether this cost included interest on the cost and depreciation of the plant.

Mr. H. Simonis said that the manufacture had been sublet, and the cost, therefore, included everything possible—and probably a considerable profit as well.

The President (Mr. J. H. Merivale) thought that there was room, both for the carrying out of Mr. Steavenson's suggestion, and for such appliances as those put forward by Mr. O. Simonis, Mr. G. A. Meyer, Mr. W. E. Garforth, and others; more especially if they could be perfected or brought nearer to perfection. Dr. Oliver's remarks had been most interesting, and he had no idea that it was possible for an animal to become immune to carbon monoxide, and to breathe air containing that gas. Consequently, if an animal could breathe a large percentage of carbon monoxide, it seemed reasonable to suppose it possible that a man could become accustomed to breathe much larger proportions than at present. This was a most important point, and no doubt would be followed up by those gentlemen who were making a study of this question.

Mr. T. J. Gueritte's paper on "Ferro-concrete and its Applications" was read as follows:—

FERRO-CONCRETE AND ITS APPLICATIONS.

By T. J. GUERITTE, C.E., B.Sc., M.Inst.C.E. (France).

Concrete, as is well known, has a high coefficient of resistance to compressive strains, but its resistance to tensile or shearing strains is low, and it would be very uncertain to rely upon it. On the other hand, iron and steel have a high resistance to com-

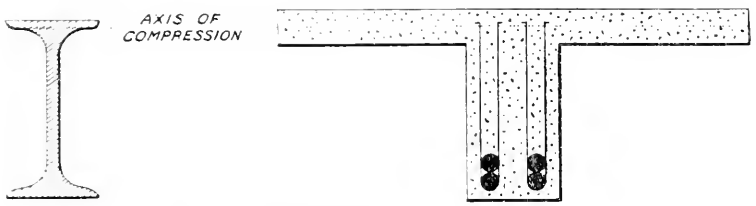


Fig. 1.—Ferro-concrete and Iron Beams.

pressive tensile and shearing strains. It is, therefore, a natural thing to try to compensate the shortcomings of concrete by the use of steel: that is, to use concrete in a structure wherever there is compression; and to meet the shearing and tensile stresses where they occur by means of iron or steel.

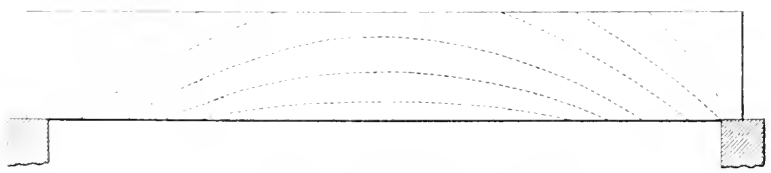


Fig. 2.—Shearing-stresses in a Beam.

Such is, in a few words, the principle of ferro-concrete construction. If, therefore, a ferro-concrete beam be compared with a rolled joist (fig. 1), the steel rods placed in the lower parts represent the line of traction which, in the rolled joist, is constituted by the lower flange. The concrete which forms the flooring above the beams is relied upon to resist the compressive strain, and may be considered as playing the part of the upper

flange of the rolled joist. The web is formed by the concrete, which encases the bars and connects the axis of compression to the axis of tension. But concrete alone would not be sufficient for the purpose, as it would not resist the shearing stresses.

The effect of shearing stresses is to provoke the formation of cracks in the beam. These cracks make an angle of nearly 45 degrees with the horizontal near the supports; this angle decreases from the supports to the middle of the span (fig. 2). In order to meet these stresses, stirrups made of hoop-steel (fig. 3) are fixed on the lower bar, and, being disposed vertically (fig. 4), connect the axis of compression with the axis of tension

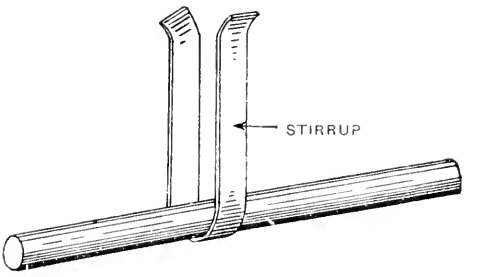


FIG. 3.—STIRRUP AND ROD.

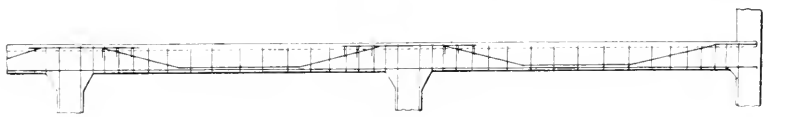


FIG. 4. FERRO-CONCRETE BEAMS AND PILLARS.

and oppose the formation of cracks which, without them, would be the result of the action of shearing stresses. In most ferro-concrete structures the beams are continuous, and practice shows that it is possible and certainly very economical to consider them as semi-fixed at both ends instead of supported only. But then tensile stresses appear at the upper part, near the supports. Steel will therefore be necessary there, and one of the best ways to provide for it is to bring diagonally to the upper part of the beam some of the bars which were at the bottom in the middle of the span and which are not required any more near the supports: for in such a beam there is near the supports no tensile strain on the lower parts, as it is confined to the upper portion. This disposition (fig. 4), and the triangle thus formed, gives great rigidity to the whole structure.

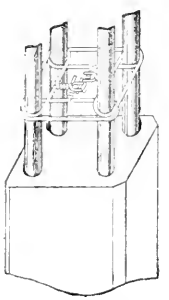


FIG. 5.—FERRO-CONCRETE PILLAR.

The writer's remarks about beams applies, of course, equally to the flooring itself which may be considered as a beam, very wide and of small depth.

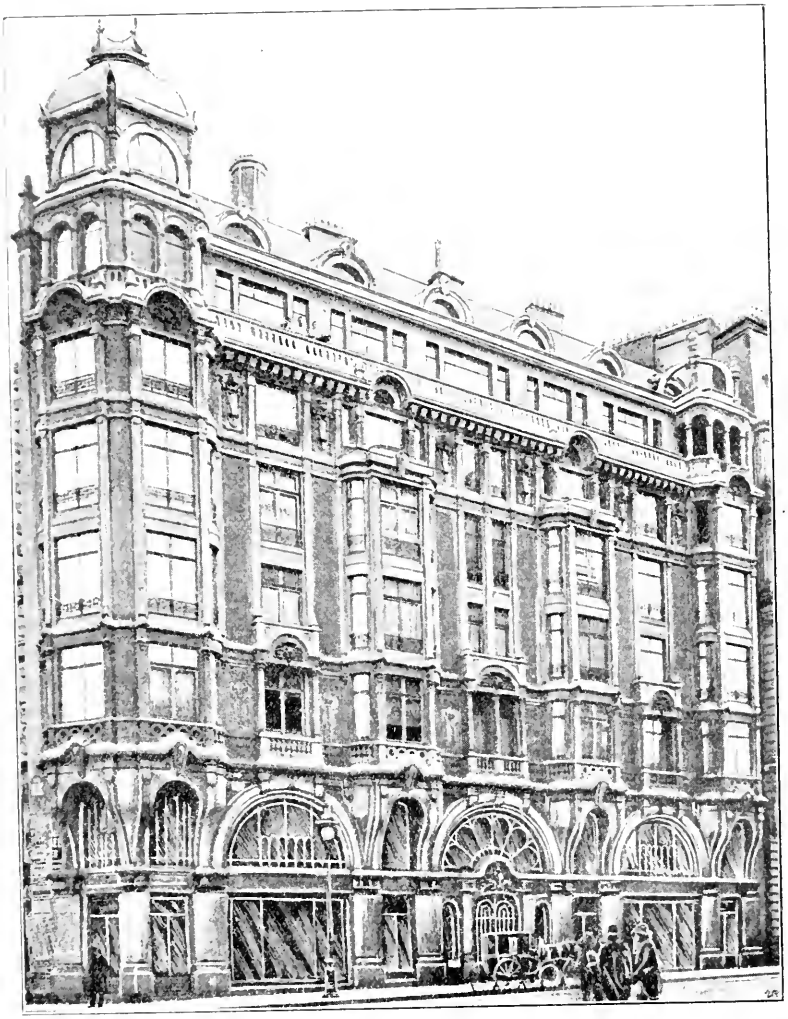


Fig. 6. Dwelling-house, Rue Danton, Paris.

The pillars form the most important component parts of a ferro-concrete building. A pillar, generally speaking, is submitted only to compressive strains, and therefore both concrete and steel are suitable for its formation (fig. 5). Bars varying in

number and size are embedded in a block of concrete: therefore both elements work together, and each of them takes part of the load to be supported.

The first applications of ferro-concrete construction were, the writer believes, made in the shape of fireproof floors, pillars and walls. But these applications belong more to architecture (fig. 6) than to engineering, and he will not, therefore, add anything to the general principles already described.

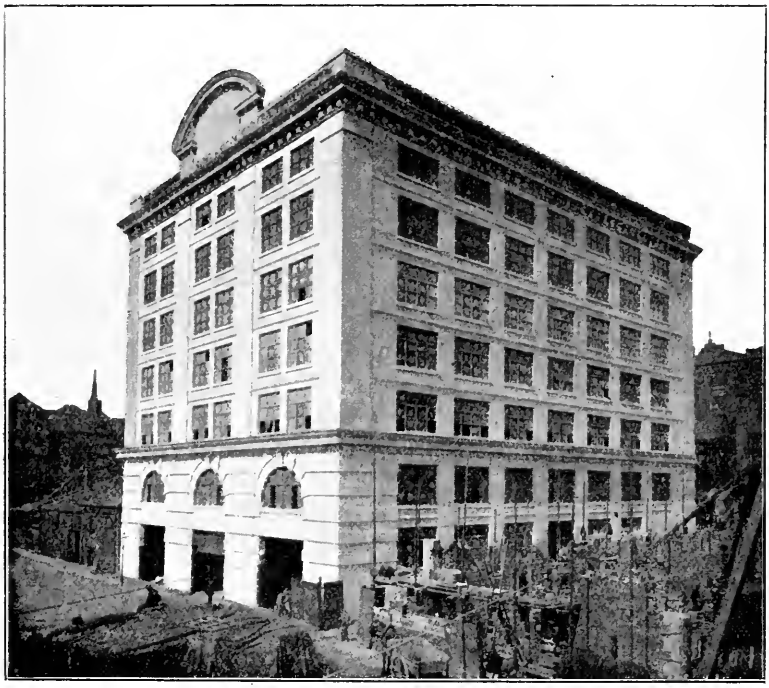


FIG. 7.—WAREHOUSE FOR CO-OPERATIVE WHOLESALE SOCIETY, LIMITED, NEWCASTLE-UPON-TYNE.

There is a question which the writer thinks is of interest, namely, that of very bad foundations in which settlements are anticipated on account, for instance, of colliery-workings in the immediate vicinity. Here, ferro-concrete has been found to be a most useful and economical solution of the problem. To illustrate this view, the writer will take the case of a building entirely built of ferro-concrete on the Quay, at Newcastle-upon-Tyne. This is an eight-storey building, and each floor has to carry the

enormous weight of 6 cwts. per square foot (fig. 7). In addition to this, the flat roof is calculated for the storage of empties and non-perishable goods. The result is that the pillars in the basement have to carry loads amounting to 600 tons, and some of them have even to support nearly 900 tons. Now, the foundations being composed of slush, peat, quicksand, etc., to a depth of 60 feet, it was evident that the foundations had to be formed either by piles driven to that depth or by cylinders, at a very great cost: it was, therefore, decided to adopt ferro-concrete. A general ferro-concrete platform was built over the whole area, spreading

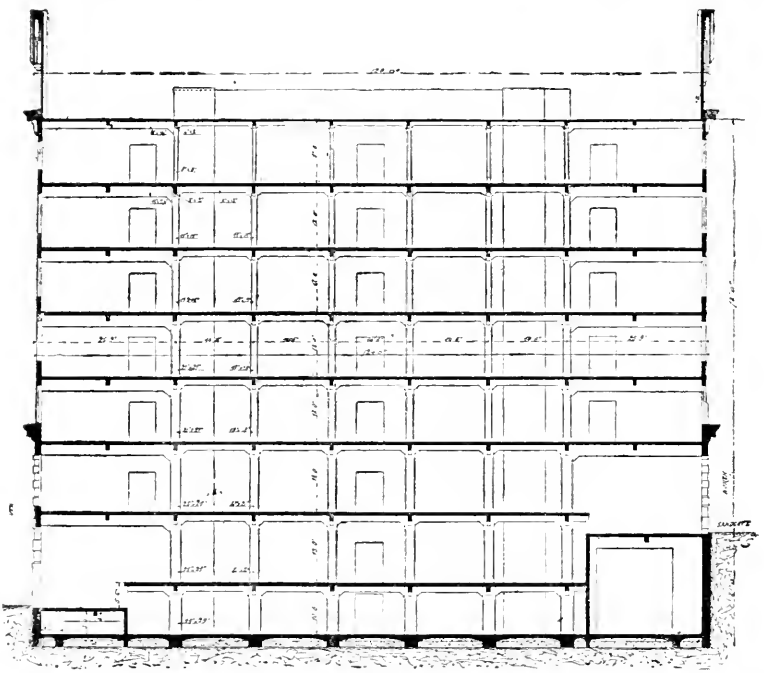


FIG. 8.—LONGITUDINAL SECTION OF WAREHOUSE. SCALE, 36 FEET TO 1 INCH.

the load at the rate of 28 tons per square yard. Of course, such a platform would have been inadequate by itself to withstand the enormous strain imposed; but by means of pillars and walls it is connected to the remainder of the building, and the whole structure forms a monolithic block, a sort of huge box-girder, 100 feet high and with a span of 130 feet. It was assumed that the whole block would sink 6 inches below its original level and without deterioration. The sinking process was carefully

watched, and it was found, ultimately, that the building had sunk as anticipated, and without ill effect on its strength (figs. 8 and 9).

Fig. 10 shows the effects of the subsidence of made ground at Bizerta, Tunis, on ferro-concrete buildings. These were restored to a horizontal position, at a lower level, by excavations.

The construction of water-tanks (fig. 11) and reservoirs offers a vast field to ferro-concrete. A list of reservoirs built on the Hennebique system alone, during the last seven years, numbers

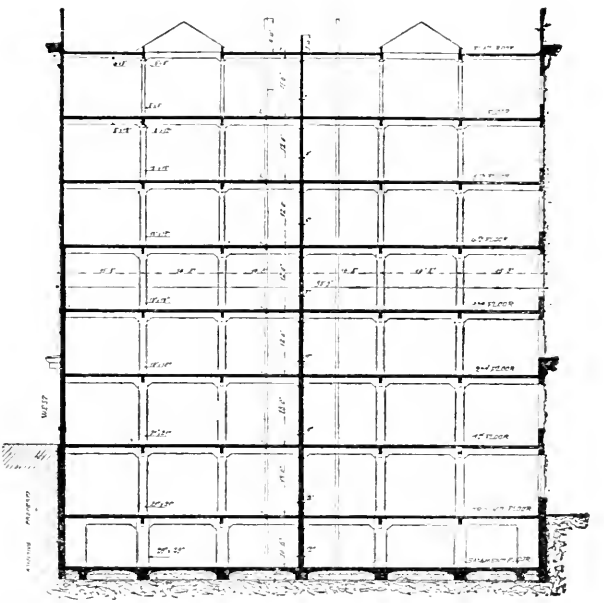


FIG. 9.—CROSS-SECTION OF WAREHOUSE. SCALE, 36 FEET TO 1 INCH.

over 1,000. This, it seems, would tend to give faith to the most sceptical. The flat roofs of ferro-concrete buildings are in many cases used as water-tanks.

A form of reservoir, of which a word must be said, is grain or coal-silos, or hoppers, the latter being of special interest (figs. 12, 13 and 14). They are calculated as a sort of reservoir, due allowance being made for the friction of the grain or coal on the walls.

Fig. 15 shows the entrance to a large culvert, 32 feet wide, at Newcastle-upon-Tyne, forming a new course for the Ouse-

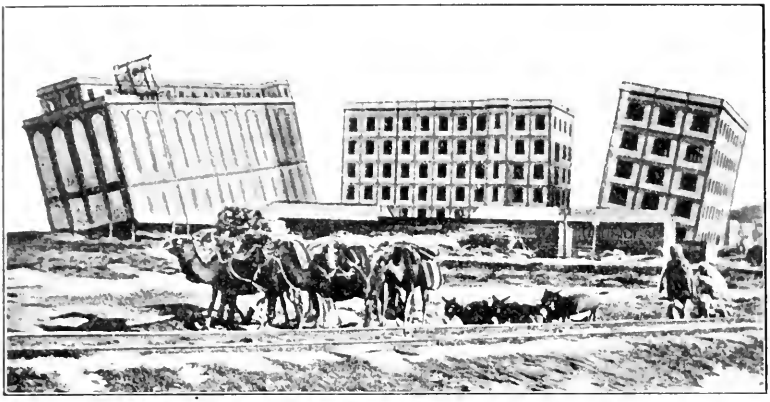


FIG. 10.—BUILDINGS FOR MANUFACTORIES, BIZERTA, TUNIS.

burn. Fig. 16 shows a ferro-concrete aqueduct for conveying water to the water-power plant at the Simplon tunnel-works.

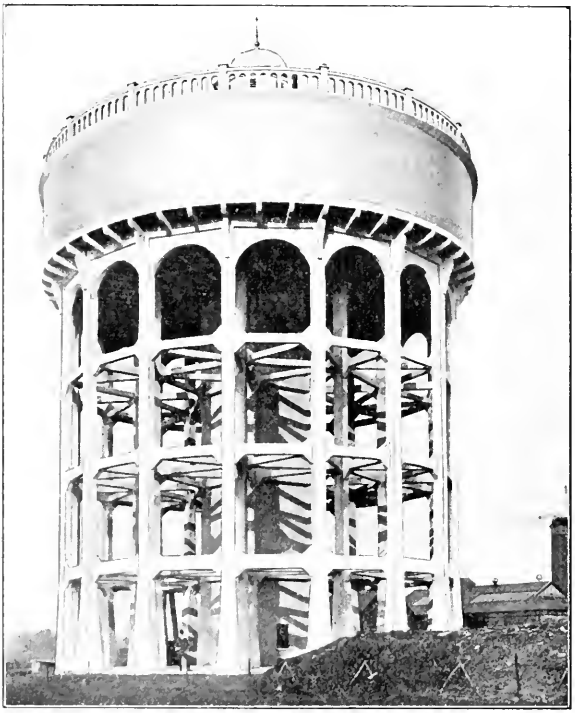


FIG. 11.—WATER-TANK AT NEWTON-LE-WILLOWS.

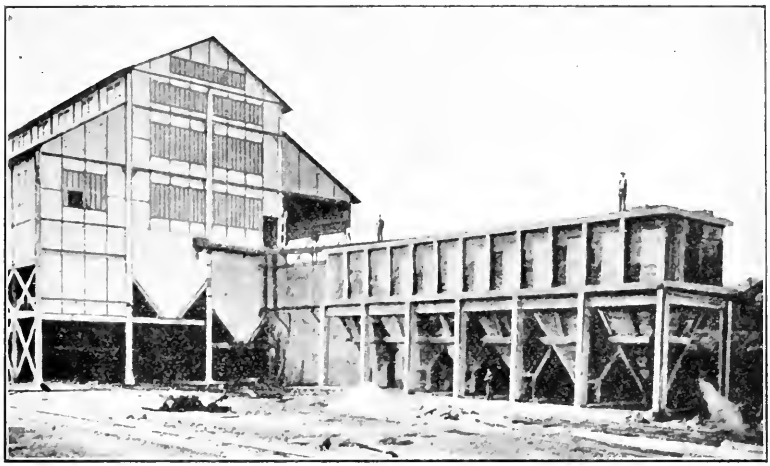


FIG. 12.—COAL-HOPPERS AT CARMAUX COLLIERIES, FRANCE.

Ferro-concrete bridges have very nearly the same appearance as metallic bridges, and are, indeed, constructed on nearly the same principles. They have a very small rise, varying from 4 per cent. to 10 per cent. of the span. The total thickness at the key is

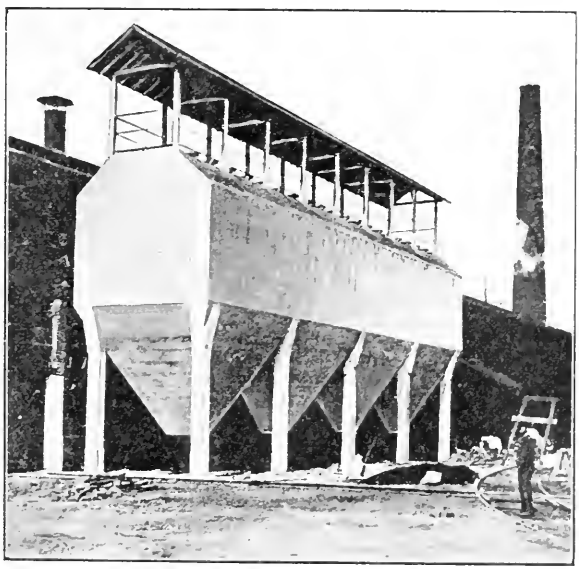


FIG. 13.—COAL-HOPPERS AT LENS COLLIERIES, FRANCE.

very small. In the Liége bridge, for instance, at the middle arch, with a span of 184 feet, the total thickness of the key is only 13 inches from the intrados of the arch to the upper part of the foot-path (fig. 17). It is evident that such a light structure offers a

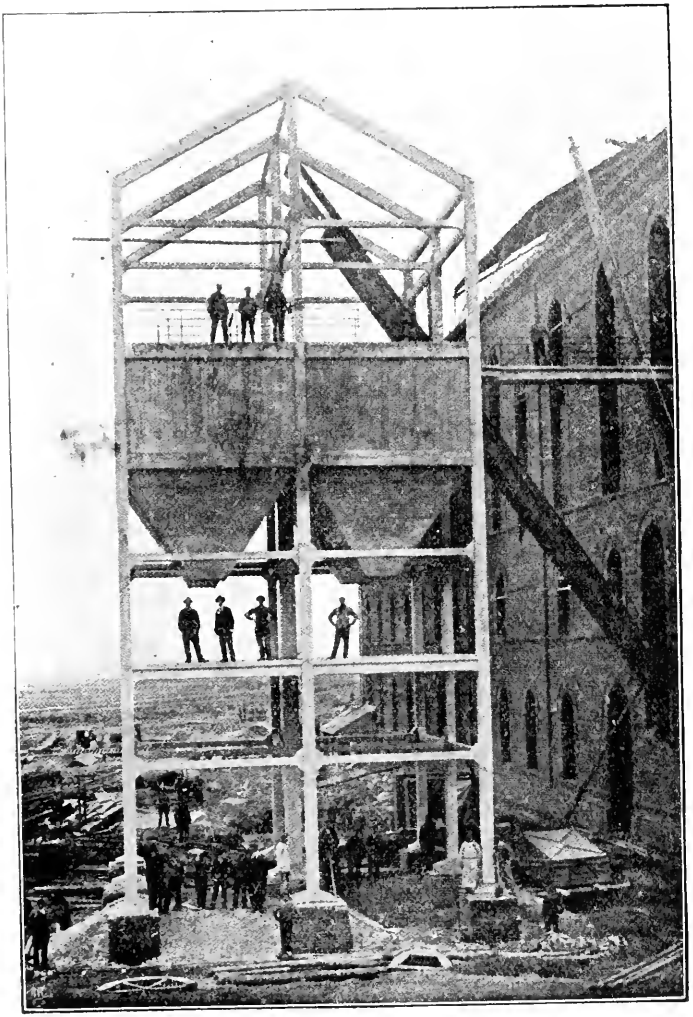


FIG. 14.—COAL-WASHING PLANT AT ANICHE COLLIERIES, FRANCE.

greater space for the passage of floods, and it is possible, therefore, to lessen by a few feet the distance between the road-level and the ordinary water-level. The consequences being a lower

gradient, and a saving in the abutments and filling for the approaches of the bridge. Another point well worthy of consideration is that the weight of a ferro-concrete bridge is much smaller than the weight of a masonry bridge, and the foundations consequently are less costly.

Some apprehension was formerly entertained as to the security offered by ferro-concrete bridges. However, the writer finds that during the last seven years more than 800 bridges have been built in Hennebique ferro-concrete, and most of these bridges have been severely tested.

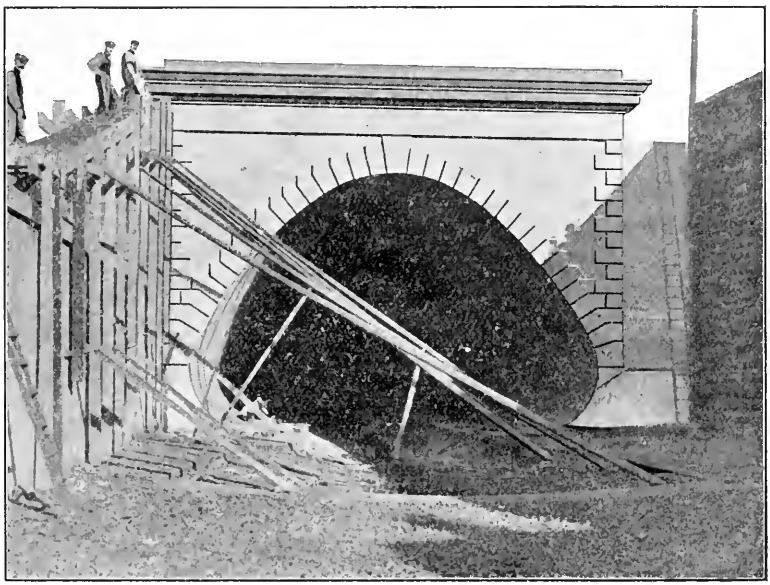


FIG. 15.—OUSEBURN CULVERT, NEWCASTLE-UPON-TYNE.

Ferro-concrete has also been applied to river and marine works (fig. 18). Most of these works contain piles and sheet-piles of ferro-concrete. Their principle of construction is somewhat analogous to that of pillars. They are consituted by a certain number of bars embedded in concrete, and maintained at the required distance apart by means of distance-pieces. Their section may vary according to the requirements from, say, 4 inches by 8 inches for very small sheet-piles, up to 20 inches square. Their length when moulded in one piece has attained

more than 65 feet. The question of weight alone prevents the moulding of longer piles in one piece; but, in cases where greater lengths are required, there are means of connecting piles moulded

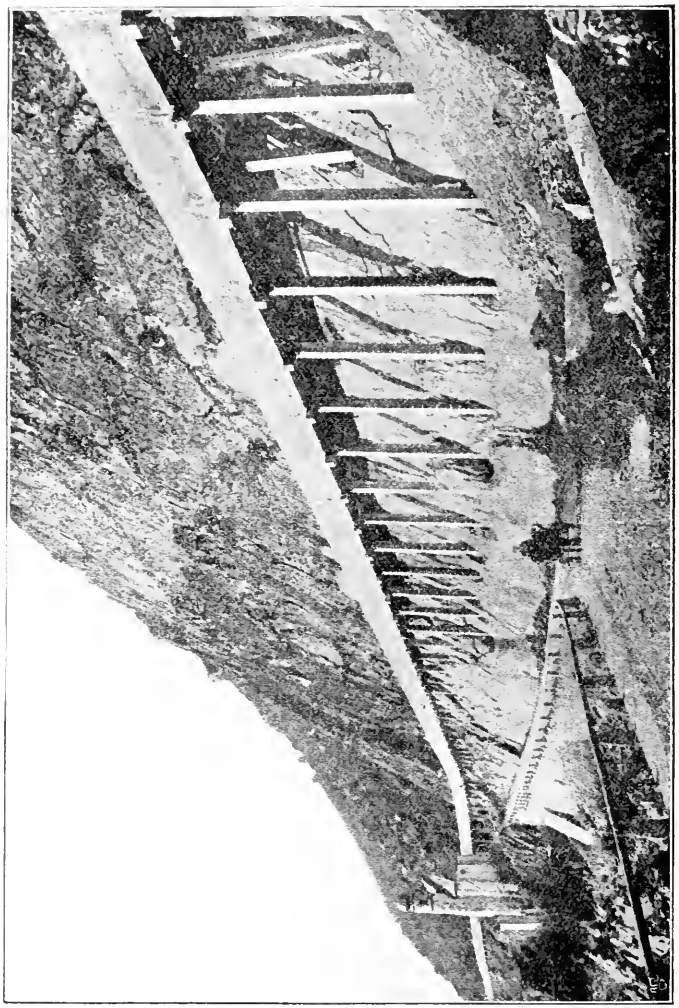


FIG. 16.—AQUEDUCT AT THE SIMPLON TUNNEL, SWITZERLAND.

beforehand, insuring a very rigid joint, and it is possible to drive ferro-concrete piles almost to any depth.

Architects sometimes object to ferro-concrete, owing to the supposed plainness of its appearance. Although engineers are

not concerned so much about æsthetics, the writer happens to

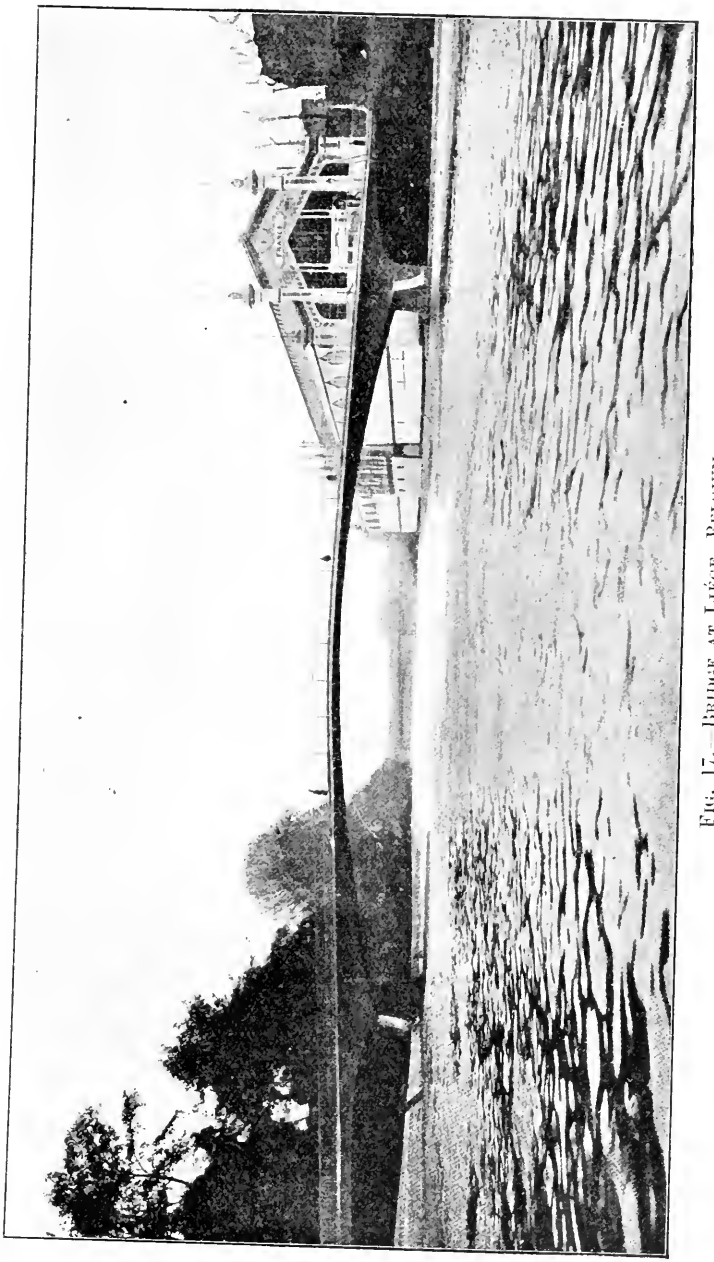


FIG. 17.—BRIDGE AT LIÉGE, BELGIUM.

know that ferro-concrete lends itself to elaborate ornamentation

in buildings (fig. 6), and as regards bridges, jetties, reservoirs, etc., it compares very favourably with other materials.

It is sometimes argued that ferro-concrete is too new a material. But ferro-concrete structures have been erected now for fifteen years without showing any sign of decay, and have been erected by thousands. Continuous vibrations, which were at first supposed to be very detrimental to ferro-concrete, do not affect it in the least. A most serious enquiry has been made on this particular point by order of the French Government, and the

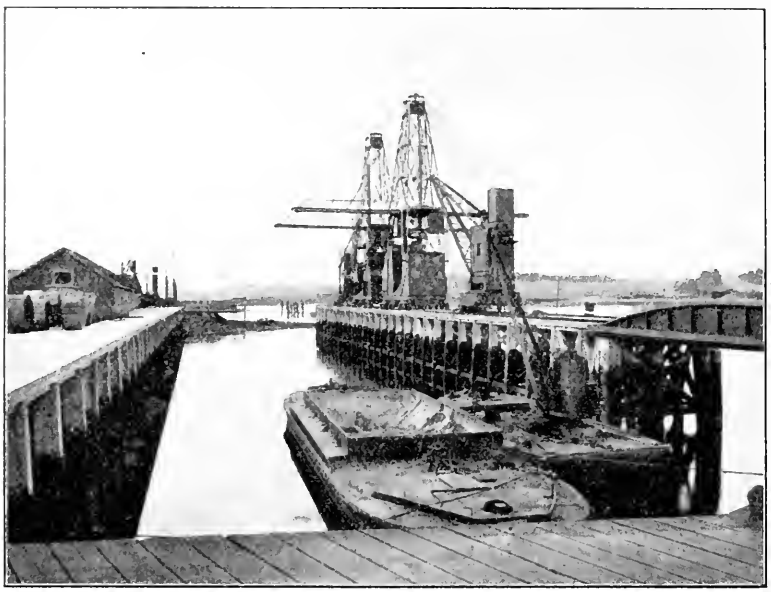


FIG. 18.—COAL-SHIPPING QUAY AND JETTY, SOUTHAMPTON.

conclusions of the report are absolutely positive. The writer need hardly state that the legend, that in course of time the steel bars become rusted in concrete and lose a great part of their strength, has been abandoned long ago, it having been proved that oxide of iron cannot exist in contact with cement. Besides, every-day practice shows that rusted bars embedded in concrete will be, in the course of a month or so, as bright as when leaving the rolling mill, the rust having been deoxidized by the formation of ferrite of calcium, which forms a protective skin all round the bars.

The adherence of concrete to iron has also been questioned. But the coefficient of adherence has now been determined, and its value is such that it justifies the practice of ferro-concrete specialists who reckon on concrete alone to make the junction between the different metallic parts of the structures. The writer means that two bars, which have to be connected, are merely set close to each other in the moulds and embedded in the concrete.

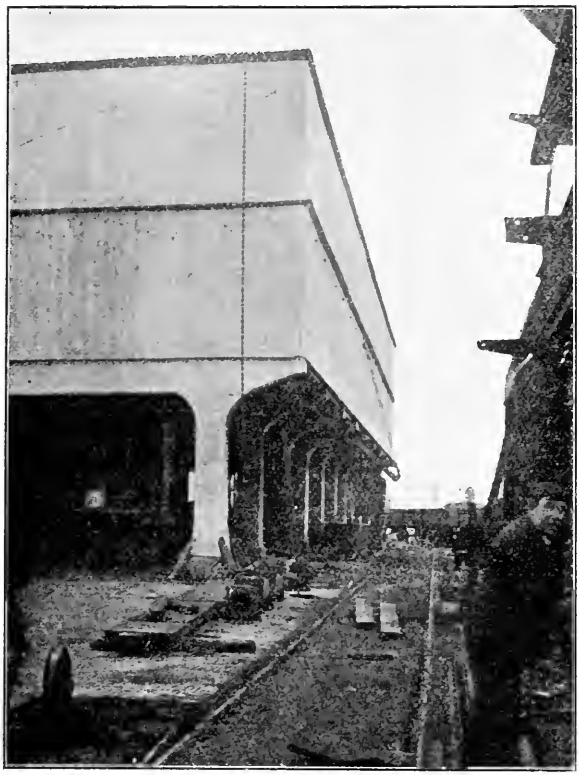


FIG. 19.—COAL-HOPPERS AT SOUTHAMPTON WITH A CAPACITY OF 4,000 TONS.

As regards the expansion of concrete and steel, their coefficients are identical up to the fifth decimal figure, and in practice it may be assumed that they are equal; consequently, in the fiercest fires, ferro-concrete resists without losing any of its qualities of strength and elasticity.

Amongst the other advantages of ferro-concrete are its cheapness, its rapidity of execution, the solidarity between all the

elements of the structure, and its durable properties which obviate almost entirely subsequent expense in upkeep, painting, etc., its absolute immunity against the attack of wood-worm, dry-rot, and damp-rot, and the like.

The writer will close by repeating the words by which the chairman of the committee of research on ferro-concrete, instituted by the French Government, characterized ferro-concrete:—"Masonry has its weakness, which is insuperable, namely, the joint; metallic structures have also an insuperable source of weakness, the rivet; ferro-concrete presents no joints and does not rely on rivets, it is not made of pieces jointed or fitted together, it is a block."

The PRESIDENT (Mr. J. H. Merivale) moved a vote of thanks to Mr. Gueritte for his instructive paper.

Prof. H. LOUIS seconded the resolution, which was cordially approved.

THE NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

GENERAL MEETING,
HELD IN THE WOOD MEMORIAL HALL, NEWCASTLE-UPON-TYNE,
APRIL 13TH, 1907.

MR. J. H. MERIVALE, PRESIDENT, IN THE CHAIR.

The SECRETARY read the minutes of the last General Meeting and reported the proceedings of the Council at their meetings on March 22nd and that day.

The following gentlemen were elected, having been previously nominated:—

MEMBERS—

Mr. THOMAS ARNOLD, Civil and Mining Engineer, Castle Buildings, Llanelly.

Mr. SIMPSON CROMBIE, Colliery Manager, Banks House, Durham.

Mr. ALLAN ARTHUR DAVIDSON, Mining Engineer, c o Mr. F. F. Fuller, 138, Salisbury House, London, E.C.

Mr. WILLIAM DICK, Consulting Engineer, 190, Palmerston House, Old Broad Street, London, E.C.

Mr. LIONEL ASHER JACOBS, Colliery Manager, E. I. R. Collieries, Giridih, Bengal, India.

Mr. EVAN JONES, Quarry Manager, Bryn Golen, Station Road, Festiniog, Blaenau Festiniog.

Mr. HENRY STUART MARTIN, Mining Engineer, Trewern, Dowlais.

Mr. LEBERECHT FERDINAND RICHARD SCHNABEL, Consulting Mechanical Engineer, Salisbury Buildings, 443, Bourke Street, Melbourne, Victoria, Australia.

Mr. DANIEL SNEDDON, Colliery Manager, 73, Scott Street, Newcastle, New South Wales, Australia.

Mr. NEIL TAYLOR, Mechanical Engineer, 58, Frederick Street, Loughborough.

Mr. ISAAC WILLIAMS, Mining and Quarrying Engineer, Elterwater, Ambleside.

Mr. ROBERT WOOD, Colliery Manager, 8, Olympia Gardens, Morpeth.

ASSOCIATE MEMBER—

Mr. HANS VON LOEWENSTEIN ZU LOEWENSTEIN, Friedrichstrasse, 2, Essen-Ruhr, Germany.

ASSOCIATES

Mr. THOMAS BATES, Under-manager, West Wylam Terrace, Prudhoe, Ovingham, S.O., Northumberland.

Mr. CHRISTOPHER ROBINSON, Back-overman, Dudley Colliery, Dudley, S.O., Northumberland.

Mr. ROBERT WARDLE, Under-manager, Edgewell Terrace, Prudhoe, Ovingham, S.O., Northumberland.

Mr. FOSTER WILLIAMS, Assistant Mine- and Quarry-manager, Rothay Cottage, Grasmere, S.O., Westmorland.

Mr. GEORGE WOOD, Back-overman, Dudley Colliery, Dudley, S.O., Northumberland.

STUDENTS—

Mr. ERNEST HODGSON KIRKUP, Mining Student, Peases West Collieries, Crook, S.O., County Durham.

Mr. THOMAS EDWARD SLATER, Mining Student, Blaydon Burn Colliery, Blaydon-upon-Tyne, S.O., County Durham.

SUBSCRIBER—

RAND MINES, LIMITED, The Corner House, Johannesburg, Transvaal.

DISCUSSION OF MR. W. E. GARFORTH'S PAPER ON "A NEW APPARATUS FOR RESCUE-WORK IN MINES."*

Mr. W. C. BLACKETT said that, from what he had seen of rescue-work at collieries, he thought that the so-called rescue-appliances would seldom come into use. He could not remember a single instance in which he would have felt safer if he had been provided with such an apparatus, or any instance where he thought a single life could have been recovered by such means. He was, however, bound to say that instances could arise, but it would be very seldom indeed: and, if they did arise so very seldom, then he was afraid that, in the course of years, the use of the apparatus would not be sufficiently practised or persisted in. Therefore from that very fact, when called upon, it would very likely constitute a source of danger. It did not seem to him that such apparatus should be lightly used. He would not like to go into any mine, for the purpose of exploration after an explosion, with the intention of putting on

* *Trans. Inst. M. E.*, 1906, vol. xxxi., page 625.

a headgear, unless he was certain that life was to be saved only in this way; and he thought that was the attitude that should be assumed. The use of such apparatus merely for the sake of re-establishing ventilation would risk a valuable life, if anything went wrong while the wearer was out of immediate reach, amid irrespirable gases. If it were known that a person was in a known place and could be reached in a certain time, under those circumstances an apparatus of this kind would be extremely useful; but the difficulty he foresaw was that men would get out of practice in its use, and he thought that if they were to establish anything in the nature of rescue-stations and appliances (as he hoped they would), they must be extremely careful that the means they used were such that they would be constantly kept in practice, and with a sort of discipline, which he feared they were not likely to get at collieries.

The PRESIDENT (Mr. J. H. Merivale) said that, at the invitation of Mr. W. E. Garforth, he and some other members of the Institute had visited the rescue-station at Altofts collieries, and he was favourably impressed with it: but he came to the conclusion that persons must be specially trained in the use of rescue-appliances. Mr. Blackett had pointed out that he would not like to use the apparatus unless there was some strong reason: but he would go further than Mr. Blackett, and would not put it on, under any circumstances, until he had had previous practical training in its use. Mr. Garforth was of opinion that there should be a rescue-station in each district: for instance, in Newcastle-upon-Tyne for Durham and Northumberland. A number of men should be trained, and each man should have his own apparatus that would fit him in the same way as his clothes did. Such men, so fitted and trained, would be, humanly speaking, absolutely safe in irrespirable gases, and could do hard work for two or three hours. These appliances were liable to get out of order; but if they were stored in a central rescue-station in Newcastle-upon-Tyne, under a trained man, they could be kept in order ready for use when necessary. He hoped that colliery-owners in their district might do something towards carrying out such an arrangement.

Mr. W. C. BLACKETT said that he was not prepared to agree that even men who were practised in the use of rescue-appliances

could put them on their heads and shoulders and be perfectly and absolutely safe. It struck him very forcibly, in reading the account of the recovery of the Courrières collieries, that not a single life was saved by the use of the apparatus and equally strongly that one life was lost. An unfortunate man, who was wearing the apparatus, was killed, and the helmet, torn off his head, was found lying by his side. This result showed that it was not to be accepted without reserve that men were perfectly safe when using such appliances. If rescue-appliances must be provided, he was prepared to suggest how that could be effected for Durham and Northumberland. It was very probable, even if men were specially trained, that untrained persons would be required to put on the apparatus: if a body of trained men went to a colliery after an explosion, they could not be turned loose in the pit without somebody to guide them, and that might be a person familiar with the workings, who might not have had any experience of rescue-appliances.

Mr. Henry Lawrence said that if it were granted that they could find an apparatus which answered all purposes for saving life without the present encumbrances, it was a very poor argument to advance that, after a time, the apparatus would get out of date, or would not be kept in proper order for work.

Mr. T. E. Forster said that he had an open mind on the matter, but until somebody showed that there was more necessity for the use of such appliances than was evident at present, he did not think that it would be desirable to provide them. He had been connected with the mines of Northumberland for many years, and could not recollect a case where such appliances were required, except at Killingworth colliery, where the Fleuss apparatus was used. The difficulty there was not, however, in getting out those who were unprovided with the apparatus, but in rescuing the man who was wearing it.

The President (Mr. J. H. Merivale) remarked that the man who was killed at the Courrières collieries was not accustomed to the use of the appliance.

DISCUSSION ON THE EXPLOSION AT WINGATE GRANGE COLLIERY.*

Mr. Donald M. D. Stuart (Bristol) wrote that the *Reports* presented a lucid description of the explosion, with perfect agreement as to its origin; and contained valuable evidence for discussing the causes of the disaster. The explosion evidently originated in coal-dust in the main intake-airway where over 26,000 cubic feet of air was passing per minute, and where gas could have no existence. Explosions of gas had been so exhaustively investigated that the conditions were known, and remedies were available in ventilation and safety-lamps that made such explosions preventible; but the dangers of coal-dust were not so well known. It was true that evidence had been accumulating for several years showing that the coal-dust deposited in mines was capable of originating and propagating explosion; but where there had been long experience of immunity from explosion in circumstances supposed to be favourable to coal-dust ignitions, it was still difficult for many to realize that explosion could be caused by coal-dust alone. Wingate Grange colliery, for example, had been worked for over 40 years without any explosion or ignition of coal-dust; and in recent years changes had been made in the ventilation and explosives, that were supposed to enhance its safety: consequently no apprehension existed that there was danger in the coal-dust. The danger now stood disclosed by the explosion, and on evidence of fact so complete that, supplemented as it was by the records of similar disasters, the mining world might be fairly asked to accept the fact that coal-dust was an explosive agent.

Many interesting questions arose, and amongst them the enquiry whether the coal-dust possessed explosive properties during the 40 years of immunity from explosion, or whether they were of recent development; it might be useful to consider the circumstances that were reported. The effect of air-currents sweeping through haulage-roads had been often observed, and here the moisture must have been largely absorbed in a period of 40 years; but in some mines both deposition of coal-dust and with-

* *Reports to His Majesty's Secretary of State for the Home Department on the Circumstances attending an Explosion which occurred at Wingate Grange Colliery, Wingate, on the 14th October, 1906*, by Mr. A. H. Ruegg, K.C., and Messrs. R. D. Bain and J. B. Atkinson, M.Sc., two of H.M. Inspectors of Mines, 1907 [Cd. 3379].

drawal of moisture were gradual, and might extend over many years before the danger-stage was reached. It also appeared that up to a recent year the mine was adequately ventilated by a fan producing 102,000 cubic feet of air per minute;* but subsequently the new fan had yielded nearly twice the quantity, namely, 193,478 cubic feet.† If this increased quantity of air was taken through the original intake-airways, the velocity of the currents must have been considerably raised, accelerating the absorption of moisture, increasing leakage from the tubs, and adding to the coal-dust deposits in the haulage-roads. One effect of the increased ventilation would therefore be dry intake-airways and a more abundant supply of coal-dust; another, the increased sensitiveness of coal-dust after exposure to air-currents, which had been observed by Prof. P. P. Bedson. These circumstances suggested that the explosive properties of the coal-dust might have been of recent development, and this was consistent with the fact that the explosion occurred after the changes in the ventilation.

He (Mr. Stuart) had found similar circumstances in his investigations of the explosions at the Camerton and Timsbury collieries. Both mines had been worked with immunity from explosion for from 70 to 100 years; but the ventilation was largely increased with no alteration in the dimensions of the intake-airways, whereupon explosive properties developed in the coal-dust distributed in the haulage-roads, and extensive explosions occurred.

The ventilation of mines had claimed principal attention in past legislation, with limitation of view to dilution and removal of gas; but the time had now come when another factor of even more disastrous energy had to be considered, since it was evident that while large quantities of air, necessarily travelling at high velocity, would dilute and render harmless noxious gases with a large margin of safety, they at the same time developed a more serious danger in creating explosive conditions throughout the main arteries of the mine, that needed only kindling at one point, to traverse the whole.

* *Reports to His Majesty's Secretary of State for the Home Department on the Circumstances attending an Explosion which occurred at Wingate Grange Colliery, Wingate, on the 14th October, 1906*, by Mr. A. H. Ruegg, K.C., and Messrs. R. D. Bain and J. B. Atkinson, M.Sc., two of H.M. Inspectors of Mines, 1907 [Cd. 3379], page 16.

† *Ibid.*, page 17.

Considerable labour had been spent for many years in the almost hopeless mission of obtaining explosives that would not ignite gas or coal-dust in mines; the subjects of dust-tight tubs and watering haulage-roads were now receiving much attention, but the potent relations of air-currents to the coal-dust question, appeared to have been overlooked. With air-currents at velocities of 400 to 800 feet per minute, and loaded tubs travelling in the opposite direction at equal speeds, depositions of coal-dust along the arteries of the mine, and development of explosive properties in the dust, appeared to be almost unavoidable; and he (Mr. Stuart) suggested that regulation of the ventilation to remove noxious gases with least effect in creating dangerous coal-dust, claimed serious attention.

The disaster threw further light on the behaviour of explosives when used in practical conditions; it was well known that detonating permitted explosives had failed to ignite coal-dust in the large number of tests and experiments made in this country, and the permitted explosives were supposed to possess a high degree of safety; it was recorded here that "a permitted explosive was only used as an extra precaution";* but this explosive unfortunately caused an explosion with coal-dust, although such an event had not happened with all the previous shot-firing. It was true that the explosive was not used as required by law; but it was used by a competent shot-firer, who had evidently been misled by the reports that detonating explosives could not ignite coal-dust. It was also true that the explosive should have been used in a properly drilled hole; but the same class of explosive was used in holes at Albion colliery, and ignited the coal-dust with an awful result. The doctrine was still taught that a detonating explosive was the safer, because its products expanded with lightning-like rapidity, and consequently cooled down before they could ignite gas or coal-dust. This theory was answered by the Wingate Grange explosion with its fatal record.

There were several very interesting observations on the propagation of the explosion. The men killed by violence were at

* *Reports to His Majesty's Secretary of State for the Home Department on the Circumstances attending an Explosion which occurred at Wingate Grange Colliery, Wingate, on the 14th October, 1906*, by Mr. A. H. Ruegg, K.C., and Messrs. R. D. Bain and J. B. Atkinson, M.Sc., two of H.M. Inspectors of Mines, 1907 [Cd. 3379], page 18.

places distant from each other, and it was not quite clear whether the authors suggested that the violence was due to a force rushing through the field of explosion, or to the sudden development of force where the men stood. It would be very useful if further information could be given on this point, and bearing upon the development of violent action also at the top of the drop staple. It was recorded that there were indications of force "between the shafts and the stable-way junction and in-bye of the junction; then, extending about 270 feet, there was a distinct length of road on which, although there were things to disturb, no disturbance had taken place; beyond the undisturbed length evidences of a renewal of disturbance were apparent."* It would be useful to know the actual position of this space of repose: the stable-way junction was marked at 720 feet from the shaft, and the shot 1,308 feet beyond the junction; while the shot-firer was found some 42 feet from the shot, bearing marks of violent forces. It was also shown that propagation failed a short distance beyond the stable way, and at 2,700 feet from the junction, in the north-east way; at the latter point abundant deposits of coked dust were observed, presumably, therefore, the propagation did not fail for want of coal-dust. It would promote the discussion of this subject if further light could be thrown on the places of failure of propagation, and the causes.

The action of Edward Murton (master shifter) and William Peat (examiner) deserved to be chronicled; and, if what they did could be embodied in "Pit Stories," for circulation amongst miners generally, such intelligence, self-reliance and courage would have far-reaching effects in keeping that standard to the front, and must have an educational value in the accidents of mining.

He (Mr. Stuart) would like to join with the members in an appreciation of this valuable contribution by the authors on the subject of colliery explosions.

Mr. Philip Kirkup (Birtley) wrote that the evidence was unanimous in proving that fire-damp did not enter into the cause, no gas ever having been reported and the point of origin

* *Reports to His Majesty's Secretary of State for the Home Department on the Circumstances attending an Explosion which occurred at Wingate Grange Colliery, Wingate, on the 14th October, 1906*, by Mr. A. H. Ruegg, K.C., and Messrs. R. D. Bain and J. B. Atkinson, M.Sc., two of H.M. Inspectors of Mines, 1907 [Cd. 3379], page 24.

being one that was very unlikely to harbour any. The evidence was also very strong, to prove that the explosion was caused entirely by an ignition of coal-dust and air, and originated from flame due to a charge of geloxite being fired on a projecting ledge of rock, probably covered by a mixture of grease and coal-dust. The roadways were described as not particularly dusty, proving that it was the very finest particles of dust that were dangerous—those which were most likely to be unobserved, such as would rest on the top of baulks and props, etc. It did not therefore appear that brushing the sides, roof, etc., would be advantageous, unless effective watering was carried on at the same time, to prevent the finer particles, thus disturbed, from being carried inbye by the air-current. Further, by removing the dust by brushing, the heavier portions, which are not dangerous, are removed, and the lighter and inflammable particles, which are too light to fall to the ground, are left. Consequently, in order to effectively deal with the dust, it should be brushed and cleared away at the same time as a water-spraying tub is working backward and forward on the inbye side; and also further assisted by fixed sprays at different parts of the roadway, fed by water from the rising main of the pumps. These appliances should produce a spray of such fineness that it would saturate the atmosphere, the moisture being carried by this means into every corner and also to the face of the workings. This water-spraying should be worked during all hours of the day, and it would also moisten dust carried in by the intake-air from the screens as well as that made from the full tubs.

The following lessons may be learnt from this explosion:—(1) The removal of coal-dust from the roadways, assisted by tub-sprays and sprays under pressure from the rising main of the pumps. (2) The thorough examination, by questions, of all shot-lighters as to their duties and the rules to be enforced, when giving out licenses. (3) The instilling of the fact into shot-lighters that, even with a permitted explosive, no shot should be fired where gas is present; and that, when using such an explosive in an unstemmed shot-hole, or where it has little work to do, it is possible to ignite coal-dust without the presence of gas. (4) Under no consideration must any charge of explosive be fired, except in a properly drilled hole, efficiently stemmed with clay. And (5) the absolute prohibition of blasting on main haulage-roads without a written authority from the manager.

Mr. C. C. Leach (Seghill) wrote that Mr. Ruegg stated that all main roads should, as far as practicable, be kept free from coal-dust. He (Mr. Leach) thought that the act of brushing the roadways with hand-brushes would raise a cloud of impalpable dust, and therefore of the most inflammable character, which would settle on the sides and roofs. This fine dust would be a greater source of danger than dust containing gritty and larger particles of coal and shale, which would tend to prevent the ignition of the dust; the gritty and larger particles forming the inert portion of it. It might, indeed, be desirable to introduce shale-dust to neutralize the coal-dust. In very hot pits, extensive watering would make it almost impossible to work in the steamy atmosphere, which would prove injurious to the health of the workmen.

Mr. J. P. Kirkup said that Mr. R. L. Galloway* appeared to question the verdict or decision of H.M. inspectors of mines and Mr. Ruegg as to the cause and origin of the Wingate explosion. He thought that mining engineers in the county of Durham, however, were generally in agreement with the report of H.M. inspectors of mines; and, had those gentlemen been present, he would have liked them to have refuted, what he might call presumptuous assertions founded, not on personal observation and knowledge, but entirely on a superficial consideration of the evidence given by the witnesses.

Mr. W. C. Blackett said that he was not surprised that explosions occurred, arising, like that at Wingate Grange colliery, out of the use of high explosives, when for so many years there had been no serious explosions from gunpowder. It was a fact that men would use high explosives under conditions where they would never have dreamt of using gunpowder, and that was the case at Wingate Grange colliery. It was futile for Mr. R. L. Galloway, or anyone else, to controvert the observations that were made at Wingate Grange colliery, as it was absolutely certain that the conclusions of H.M. inspectors of mines as to the cause of the explosion were correct. There could be no doubt that the explosion was caused by the particular shot fired under the circumstances described in the report. The man who fired the shot would never have dreamt of doing what he did if he had been

* "The Wingate Grange Explosion," by Mr. R. L. Galloway, *The Colliery Guardian*, 1907, vol. xciii., page 635.

required to use gunpowder; and therefore they had a curious anomaly, that in this case gunpowder would have been the safer. No man would place a charge of gunpowder on the top of a projecting stone, and cover it with grease and dust. The man knew that an explosive, like geloxite, containing nitroglycerine, would break down a piece of stone, and, having nothing else particular to do, he put his time in that way. There could be no doubt about the origin of the explosion.

After reading the reports on the Wingate Grange explosion, the uppermost thought in his (Mr. Blackett's) mind was the length of time wasted at the enquiry before the coroner, some of which was due to the necessity of imparting technical instruction to persons who took prominent parts therein and who were ignorant of even the elements of mining. The report of Mr. Ruegg, considering his lack of familiarity with mining, was most able; and there were few men who, under similar circumstances, could have written so clearly on the subject. What he might say, therefore, was not in disrespect to that gentleman, but was meant to find fault with a system which permitted a person, more or less completely ignorant of mining, to report in authoritative terms, and to pass opinions upon so highly technical a subject. The reports were, he supposed, intended to be records for future guidance, and as such should only be written by men who knew the subject completely; otherwise they would tend to mislead (as he thought that this one might do, and as others possibly had done), notably that written by Mr. J. E. Joel on the Brancepeth explosion.* He (Mr. Blackett) would therefore warn students against the conclusions drawn by gentlemen who came down as official reporters to the Home Secretary, and he advised them to stick to the facts related so clearly and ably by the men who knew, namely, H.M. inspectors of mines. In this case, an eminent lawyer, who might never have been inside a mine in his life, ventured to make a report on the cause of an explosion in a mine and on the means which, in his opinion, should be adopted to guard against like occurrences. He (Mr. Blackett) valued the opinion of a lawyer on law, but on mining he regarded it as merely interesting.

* *Reports to the Right Honourable the Secretary of State for the Home Department on the Circumstances attending an Explosion which occurred at the Brancepeth Colliery in the County of Durham, on the 13th of April, 1896*, by Mr. J. Edmondson Joel, Barrister-at-law, and by Mr. R. Donald Bain, H.M. Inspector of Mines, 1896 [C.-8174], pages 3 to 14.

It was instructive to hear from Mr. Ruegg's report that he was of opinion that the ventilation was sufficient, that part of the haulage-road was dusty and that the dust was dry, but this would perhaps be more correctly described as the balance of opinion of those who knew. It was also interesting to observe how reluctantly Mr. Ruegg accepted what he called the "theory," put forward by the officials of the mine with the help of expert assistance; but it was more than theory, it was a definite fact ascertained by those who knew, and scepticism was not warranted.

He (Mr. Blackett) chiefly objected to Mr. Ruegg's opinion that the system adopted by Mr. C. S. Carnes, at his collieries, of brushing down the dust with hand-brushes, if it were adopted generally, would greatly minimize the risk of explosion by coal-dust. Personally, he considered that brushing down dust was not only quite impracticable, but was more or less futile, and perhaps even somewhat dangerous. No doubt large quantities of small particles of matter might be removed in this way; but he maintained that it would be impossible to brush off from timber and other ledges so much dust as would leave a quantity so small as to be harmless, and it was dangerous to give an impression that such brushing could be effectual. Moreover, the most dangerous dust would be moved on by this means nearer and nearer to the face, carried by the air-current to a part of the mine where it would be even more objectionable than before.

If managers would only make up their minds to use water, and with a fine impalable spray wash the dust from the timber and ledges, the dust would then be effectually removed or rendered harmless for a considerable period. Water could reach places, untouched by the brush, and could be used in quantities which would have but a superficial effect, without the necessity of swilling. It was quite true that some stones would not stand water, but there were few that would not bear a superficial quantity. He thought that this danger (although freely admitting that it existed) had been made far too much of, and he was afraid that the exaggeration, in the end, would do more harm than good.

Mr. T. E. Forster said that he did not quite see himself why a lawyer should make a report on collieries; but, if the members read Mr. Ruegg's report, they would find that the opinions which he expressed were really those of H.M. inspectors of mines. He (Mr. Forster) could not understand why they were

not allowed to report alone. In this instance, Mr. Ruegg seemed to have accepted their opinions and put them forward as his own; but, on another occasion, the gentleman instructed by the Home Secretary might differ with H.M. inspectors of mines, and he might make recommendations at variance with theirs and with the general practice. The Royal Commission on Accidents in Mines, now sitting, had paid great attention to the dust-problem. The evidence was published week by week as the sittings proceeded, and was scarcely necessary to call the special attention of mining engineers to the difficulties and dangers in connection with coal-dust, for they had all been aware of them for many years. The publication of the evidence, however, would be very helpful, in so far as it would draw the attention of under-officials and shot-firers to the matter: for one knew from personal experience that these men did not read professional papers, and were not fully aware of the necessity of counteracting these dangers. He approved of the suggestion that they should be cross-examined by colliery managers from time to time. When Special Rules were established, and for some time afterwards, everybody observed them: but after a few years they were apt to be forgotten, and it was desirable that everyone's ideas should be furbished up occasionally. He thought that it would prove advantageous if copies of the reports upon the Wingate Grange explosion were distributed to managers and under-managers for careful consideration.

Mr. S. Hare, while he agreed with Mr. Blackett in almost every way in connection with the use of water, said that watering could not be adopted under all conditions, and then the only thing that could be done was to adopt brushing. For instance, watering was extensively adopted at the Murton collieries, and several miles of water-pipes, from 1 inch to $1\frac{1}{2}$ inches in diameter, had been laid, with hydrants fitted at distances varying from 150 to 250 feet apart. He was a believer in the use of water-sprays and occasionally used them. Any system of watering was, however, in his opinion of little value unless the dust was gathered together and sent out of the pit at short intervals. Brushes were used to a limited extent at the Murton collieries, but only where it was considered unsafe to apply a large quantity of water. He had adopted a system, in connection with the shot-firers, which was, he thought, worthy of emulation. In each district,

where shot-firing was allowed, printed instructions were posted for the guidance of the shot-firers and to ensure that their work should be carried out with the utmost safety. He thought that the posting of these instructions, which were of a stringent character, brought the subject very closely under their notice. In addition, the more important regulations were printed on the back of the license given to each shot-firer, and this helped to impress upon each shot-firer the necessity and the importance of the regulations that he was required to observe.

Mr. C. A. Crofton (Morpeth) said that the masterly report of H.M. inspectors of mines had convinced him that the Wingate Grange disaster was purely and simply a coal-dust explosion. He agreed with Mr. W. C. Blackett and Mr. S. Hare with regard to the watering of haulage-roads, which, although suitable in one pit, might not be so advantageous in another, on account of the nature of the strata and the depth of the pit. Coal varied considerably in its properties, moisture, etc., and tests might prove that all coal-dust would not explode, some being more highly sensitive to ignition than others. Consequently he suggested that coal-dusts from Wingate Grange and from some shallower pits might be tested. In the transportation of coal the larger pieces worked to the bottom of the tub and the dust to the top, and on meeting the intake-air the dust was blown out of the tub and deposited on the sides, timbers, roof, etc. He suggested, as a remedy, that all tubs should be fitted with a lid or cover, which would be removed from an empty tub and put by the landing-lad on a full tub, and then again would be taken off by the shaft-lad and placed in an empty tub. Catches would be fitted on the tubs to prevent the lids from being blown off the tubs. He thought that this method might prevent the formation of 80 per cent. of the dust at present being deposited.

Mr. James Ashworth (Old Colwyn) wrote that it would interest him, and doubtless many other engineers, to have additional information as to the part played by steam. It was stated that the steam-pipes were broken; that the steam from three ranges of pipes was added to the after-damp; and that one survivor, J. McDougall, who escaped alive, was scalded by steam in the Main coal-seam, whilst his mate, J. G. Dixon, was killed by force: was this force from the steam or from the explosion? It might be concluded, after reading the reports, that the flame

of the explosion went down the stable way and burned G. Bloomfield, but not the horse found dead near to him. He (Mr. Ashworth) would, therefore, like to know whether the appearance of Bloomfield might not be due to scalding, and not to burning; more particularly because the horse was not singed, neither were any of the horses singed in the stable. But it was quite conceivable that steam and after-damp were either jointly or severally the cause of their deaths. At Elemore colliery, an explosion, originating in a similar way, was carried down the shafts to the mines below; and therefore, if the dust from the screens made the Low Main haulage-ways dangerous, the shafts themselves must have been still more dangerous, as a consequence of the larger volume of air passing down to the lower mines. In his (Mr. Ashworth's) opinion, the steam saved the lower mines; as no form of water, excepting steam, could saturate an air-current sufficiently to place a barrier in front of a gas or dust explosion. Roughly estimated, air would have to contain over 5 per cent. of water-vapour, or, say, 26 grains per cubic foot, before it could exercise any controlling influence.* Not only did the steam, in this way, serve a most useful purpose as a life-saving agent, but it also appeared to have brought the explosion to a conclusion, before it extended into the second east way, by its effect on the ventilation. Thus, the large volume of steam struggling to escape in every direction, particularly downwards, and acting in like manner as the steam-jet of an injector, might for the time have reversed the ventilation in the Low Main coal-seam: that was to say, both the intake- and return-airways were brought under an influence tending to draw back the intake-air, and to force the return-air down the Harvey staple. The next phase would be during the period of condensation, when air struggling to enter from every direction to fill the void, tended to draw back the advancing flame, supposing that the effect of the steam in the shaft had not already caused the arrestment of the advancing flame by the large volume of dust disturbed. It was a most marked feature in this explosion that the explorers experienced very little trouble from after-damp; and that the men escaping from the second east district also met very little after-damp, or they could not have travelled such long distances before succumbing. He (Mr. Ashworth) regretted that the plans attached to the *Reports* did not

* "The Rate of Explosions in Gases," by Prof. H. B. Dixon, *Trans. Inst. M. E.*, 1892, vol. iii., page 317.

indicate the doors, stoppings, and air-crossings that had been blown out, and consequently where, in addition to the blown-out casing in the upcast-shaft, the air short-circuited after the explosion. For the foregoing reasons, he (Mr. Ashworth) had concluded that excess of dust had brought the flame to an end, and not want of dust, particularly as the greatest heat-effects were demonstrated close to the point where the explosion appears to have terminated; and moreover some at least of the great force exhibited between the shafts and the stable way, must have been due to the escaping steam. He was also of opinion that, had it been possible for the first band of explorers to descend to the Low Main seam sooner than they did, and check the escape of air into the upcast-shaft, most of the men in the north-east way would have escaped alive.

The hygrometrical observations* were interesting, as they showed that the intake-air at the shafts was saturated with water; and, although there was a difference of 1·2 grains between the observations made on October 22nd and those made on November 9th, 1906, yet when the air reached the curve of the second east way, the water-content had risen to 6·2 grains per cubic foot, being on the first date 0·4 grain, and on the latter date 0·2 grain only, below absolute saturation. Therefore, it was doubtful whether it was correct to call either the dust or the atmosphere "dry." At the place where Bloomfield was found, the air was saturated, and carried 6·3 grains of water per cubic foot of air. It was perfectly clear that air saturated with moisture was no protection against the extension of an explosion. On the other hand, it assisted in the oxidation process; and, moreover, in addition, the explosion was reported to have passed over two wet places, of considerable length, although neither of these were indicated on the plans accompanying the *Reports*. With these facts so plainly demonstrated, it was a misnomer to describe the part of the mine traversed by the explosion as "dry."

The analyses of dust were another interesting feature of the *Reports*, but they did not throw any distinct light on the question, as to whether dust containing a certain proportion of ash was explosive or not.† For instance, the dust near Maddison's shot

* *Reports to His Majesty's Secretary of State for the Home Department on the Circumstances attending an Explosion which occurred at Wingate Grange Colliery, Wingate, on the 14th October, 1906*, by Mr. A. H. Ruegg, K.C., and Messrs. R. D. Bain and J. B. Atkinson, M.Sc., two of H.M. Inspectors of Mines, 1907 [Cd. 3379], page 30.

† *Ibid.*, page 35.

contained 44·13 per cent. of ash; and at the point near the end of the explosion on the stable way, 34·80, 39·20 and 44·14 per cent., and in the north district, near the end of the explosion, only 26·95 per cent. These values, when compared with those obtained at Camerton, Courrières and other collieries, did not demonstrate that such percentages of ash were a safe factor. The addition of an analysis of the coal of the different seams would have been useful for purposes of comparison.

Possibly no disaster would have resulted from the shot, if Maddison had not used greasy dust from the roadway to cover the charge, and it was in all probability the great flame from this, as at Timsbury colliery, that really originated the disaster.

Mr. A. M. Hedley (Blaydon Burn) wrote that, during the discussion on the *Reports* dealing with the Wingate Grange colliery explosion, Mr. C. C. Leach raised objection to brushing the main roadways as it "would raise a cloud of impalpable dust, and therefore of the most inflammable character, which would settle on the sides and roofs."* Views differed considerably as to the necessity for, or practicability of, keeping all main roads entirely clear of dust throughout their full length; but, in his (Mr. Hedley's) opinion, every dry and dusty colliery should have its roadways dealt with as far as possible in this direction, and he thought that the idea was sound of having, at any rate, certain lengths of the road kept at intervals clear of dust. Surely few engineers would contend that there was no necessity for removing the dust which accumulated in the main roadways, and to his mind the only point in doubt appeared to be the means to be adopted for its removal. Mr. W. C. Blackett was of opinion that "brushing down" was "impracticable" . . . . "and perhaps even somewhat dangerous."† Mr. Blackett favoured, however, the system of watering, for the purpose of washing off the light dust which had accumulated on the roof and sides; and a similar expression of opinion from Mr. Hare, with the latter's extensive experience at Murton, should carry considerable weight.

An effective combination, if feasible, of brushing and watering seemed desirable, and he (Mr. Hedley) wished to recommend a means of accomplishing this object which had recently been suggested to him by Mr. R. Crombie, an associate of the Institute. It was an idea which the latter had previously carried

* *Trans. Inst. M.E.*, 1907, vol. xxxiii., page 188. † *Ibid.*, page 190.

out, and he (Mr. Hedley) had since tried it with satisfactory results. He would assume that a length of 300 feet was required to be cleared of dust on a main haulage-road, which at the same time served as an intake-airway. On the inbye side (or the outbye side, if a return-airway) of this area to be treated, a piece of brattice-cloth, thoroughly soaked in water, was attached along its upper edge to the roof-timber, across the full width of the road. It was hung at such a distance from the roof as was deemed necessary, without offering too great an obstruction to the ventilating current; and, in the case of a strong current of air, the canvas should be weighted by attaching pieces of timber to its lower edge. When the brattice-cloth was fixed, the dust-zone was treated by water-sprays to such an extent as the nature of the seam's roof or thill would allow, and it was then found that the operation of brushing the dust from the roof and sides could be carried out with impunity. The light dust raised, if carried forward by the air-current, would, on meeting the wet canvas-obstruction, be moistened and fall in layers on to the floor, whence, with the bottom dirt, it could be removed and filled into a tub when the operation was completed. Possibly a succession of wet sheets might even give better results, and wet canvas stretched along the roof and sides would further improve matters. It was possible that one sheet, treated with a continuous spray of water throughout the brushing operation, would answer the required purpose. It appeared to him (Mr. Hedley) that the efficacy of this treatment in the final capture of the fine dust depended on the fact that the dust was driven against a wet surface, instead of the water being thrown on to the dust and so acting as an agitating and disturbing agent.

The PRESIDENT (Mr. J. H. Merivale) said that the chief point brought out by the reports on the Wingate Grange explosion was the danger from coal-dust. It seemed a truism that there was danger connected with coal-dust, but on reading the *Reports* it appeared that many persons still are, or at any rate were, in doubt as to the dangers connected with it. He agreed with Mr. W. C. Blackett to some extent as to the undesirability of bringing down gentlemen ignorant of mining matters to report on colliery explosions. Perhaps the classical instance was that of Haswell colliery in 1844, when Sir Charles Lyell and Prof.

Michael Faraday, two of the most eminent men of the day, advised mining engineers to put in pipes to drain gases from the goaves. If, however, an able man, who had no prejudices and knew nothing about mining, presided at an enquiry and heard all that was said on both sides, he was in a good position to form an opinion.

DISCUSSION OF MR. E. SEYMOUR WOOD'S PAPER ON "SINKING THROUGH MAGNESIAN LIMESTONE AND YELLOW SAND BY THE FREEZING-PROCESS AT DAWDON COLLIERY, NEAR SEAHAM HARBOUR, COUNTY DURHAM."*

Mr. James H. Brace (New York) wrote that, while this work was entirely successful, it appeared (1) to emphasize the necessity of keeping the borings plumb and at a uniform distance; and that (2) it was very difficult to form an ice-wall while water was running through the material to be frozen, and that every precaution should be taken to stop any such flow before starting freezing. He understood that the contractors for the work described had had wide experience of this kind of work, and he would like to enquire what experiments had been made with lower temperatures. With the machinery now in use, it was practicable to reduce the temperature of the brine down to −30° Fahr., and it would seem to be advantageous to make it as low as practicable. In conclusion, there had, so far as he knew, been only two applications of the freezing process for excavation in America in recent years. One of these was on the rapid-transit tunnel between New York and Brooklyn. This had recently been fully described in the technical press;† and the other work had not as yet reached a final stage.

Mr. M. Malplat's paper on "Sliding-trough Conveyors" was read as follows:—

* *Trans. Inst. M. E.*, 1906, vol. xxxii., page 551.

† "The Freezing Process in the Battery Tunnel, New York," *The Engineering Record* [New York], 1906, vol. liv., page 656.

SLIDING-TROUGH CONVEYORS.*

By M. MALPLAT.

At the present time, in No. 7 pit of the Lens collieries, the Saint-Augustin seam is being worked, with the following characteristics:—The seam is formed of one single bed of coal, varying from 20 to 24 inches (0·5 to 0·6 metre) thick in the more regular portions. The coal is hard, but it generally cleaves into big blocks, without bedding. The roof is bad, and the floor variable. The average dip is 11 degrees.

The method originally adopted for working this seam was by means of rising gateways, 52 feet (16 metres) wide, with a road in the middle of each. The working-cost of this system was somewhat high, as the essential elements, namely, the hewing of the coal and the opening of the roads, were expensive. The stone taken up in the roads must be thick, because the seam is thin; and, in addition, each foot of roadway corresponds only to a small output of coal. In order to reduce the costs of stone-work, the management were induced to suppress every alternate road, giving each working-face a length of 100 feet (30 metres). It then became indispensable to establish, on either side of the face, which measured 50 feet (15 metres), some method of conveying the coals.

The following system was adopted:—The coal-face, at each side of the rising gateway, is made at a small angle with the strike of the seam, and with a slight slope towards the road; and, in the space between the coal-face and the goaf, rails weighing 10 pounds per yard (5 kilogrammes per metre) have been laid (Fig. 1). The gauge of the rails is $9\frac{1}{2}$ inches (24 centimetres); they are connected by riveted sleepers, and form lengths of $8\frac{1}{4}$ feet ($2\frac{1}{2}$ metres), fitted to the neighbouring lengths by means of fish-plates. Along this road slides a trough made

* "L'Emploi . . . . de Couloirs glissants pour le Boutage dans les Tailles," by Mr. M. Malplat, *Comptes rendus mensuels des Réunions de la Société de l'Industrie Minérale*, 1907, pages 27-28.—Translated by Prof. Henry Louis, M.A.

of sheet-iron, 0·12 inch (3 millimetres) thick, in the form of a semi-cylinder, 20 inches (50 centimetres) in diameter and 6½ feet (2 metres) long. This trough is protected by three rings of half-round iron, which rest upon the rails (Fig. 2). A rope, 50 feet (15 metres) long is attached to each end of the trough, and allows it to be drawn alternately from the further end of either side of the face to the road.

The working is organized as follows:—Five workmen, one of whom is an assistant, are engaged at the face. The assistant works in the roadway, drags the troughs when they are full, and loads the coals into the tubs. The amount of pull required to move the trough is very small, and it is about the same in either direction, full or empty, on account of the gentle slope of the road. Unloading the trough is particularly easy, when, as is the present case, the cut for the roadway is made in the

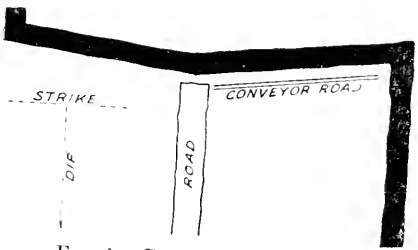


FIG. 1.—PLAN OF GATEWAY.
SCALE, 48 FEET TO 1 INCH.

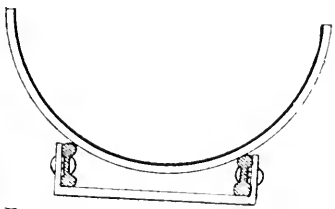


FIG. 2.—SECTION OF CONVEYOR.
SCALE, 12 INCHES TO 1 INCH.

bottom-stone. The trough is tipped into the tub standing in the roadway by attaching the rear cord of the trough to a prop at the far end of the face; and, by suitably regulating the length of this cord, the trough can be abruptly stopped, producing automatic discharge of the contents. In this method of discharge, the trough is open at either end; but often, on the contrary, in order to increase its capacity, the lower end is closed by a movable door. The trough has a capacity of about 3½ cubic feet (2 hectolitres); in practice, three troughs fill a tub carrying 10½ cwts. (545 kilogrammes); and two troughs are sufficient when the seam is thicker, and the trough can be loaded above the level of its edges. Very little height is required, as the trough will pass under a height of 14 inches (0·35 metre).

The system has been well received by the workmen, who found formerly that the transport of the coal was laborious on

account of the thinness of the seam. The coal is loaded, as fast as it is broken down, into the trough, and the face always remains free for the ventilating current and the passage of the miners. The width of the working-face of each gateway has been doubled without increase of the hewing prices, and no payment is made for laying the road for the conveyor. These troughs are also used for throwing back into the goaf the débris made in cutting the roads, part of which was formerly sent to bank in tubs.

Mr. T. C. Futers said that the trough, merely lying on the rails and having a capacity of 3½ cwts., would require a strong boy to move it.

Mr. Henry Lawrence said that the appliance seemed a very unusual one: its adoption might have been necessary under the circumstances in which it was employed, but he thought that friction would soon wear out the trough.

Mr. T. E. Forster asked what strain or pull was required to move the empty and the loaded trough, whether the system had been in use any length of time, and the cost of this method of conveying.

Mr. C. A. Crofton remarked that tubs carrying 10½ cwts. were rather large for a seam less than 2 feet high. The stone-work would consequently be very costly.

The President (Mr. J. H. Merivale) said that the method had evidently been developed, in order to reduce the cost of working thin seams by decreasing the number of gateways. Attempts had been made, some with considerable success, and others with not so much; and one could hardly tell from a cursory glance whether this proposal was likely to prove successful.

Mr. M. Walton Brown read the following "Memoir of the late John Daglish."

MEMOIR OF THE LATE JOHN DAGLISH.

By M. WALTON BROWN.*

The late Mr. John Daglish, mining and civil engineer, of Rothley Crag, Cambo, Northumberland, was born in Newcastle-upon-Tyne, on June 26th, 1828. He attended Dr. John Collingwood Bruce's school in Newcastle-upon-Tyne from 1836 to 1838. Afterwards he went to Wesley College, Sheffield, where he remained until 1843; and during that year he commenced his apprenticeship as a mining engineer with Mr. Nicholas Wood, at Killingworth collieries. In 1848, he went to Urpeth colliery, as assistant viewer to Mr. Edward Fenwick Boyd: and from October 1849 to 1850, he attended lectures at King's and University Colleges, London.

In 1850, he went to Barrington colliery, as viewer, under Mr. James Longridge: and, in 1852, he was appointed viewer of Radcliffe colliery. In October, 1854, he was appointed viewer of Seaton colliery, then the property of the Earl of Durham and the Owners of Hetton collieries.

In 1855, he married Miss Sarah Ellen Robson of Paradise, near Newcastle-upon-Tyne, and of the marriage there was one daughter, Adelaide Mary, who was born at Seaton House on December 28th, 1856, and died at Rothley Crag in 1905.

Mr. Daglish became viewer of the Hetton collieries in 1859 He was in 1863 appointed chief viewer to the collieries belonging to the Marchioness of Londonderry: in 1865, he became general manager: and he resigned this position in 1869.

He became managing director of the Whitburn colliery in 1873: and in the same year, he was appointed managing director of Cwmaman colliery, in South Wales, and held the appointment until his resignation in 1895. He was also agent for Kimblesworth colliery, Durham: Silksworth colliery, Durham; Houghton Main colliery, Yorkshire; Swaithe Main colliery, Yorkshire:

* Extended and revised from the *Newcastle Daily Journal*, August 16th, 1906, page 5.

and Manvers Main colliery, Yorkshire. He was a director of Llest colliery, South Wales; and as check viewer held numerous mining agencies.

In July, 1891, Mr. Daglish resigned all colliery management, and purchased the Rothley Crag estate of 1,100 acres. The building of the hall at Rothley Crag was completed in 1895, and here he chiefly resided until his death.

He was one of the 44 "colliery owners, viewers and others interested in the coal trade," who met in Newcastle-upon-Tyne, on July 3rd, 1852, and founded The North of England Institute of Mining and Mechanical Engineers, "to meet at fixed periods and discuss the means for the ventilation of coal-mines, for the prevention of accidents, and for general purposes connected with the winning and working of collieries." He retained his membership up to his death, and at all times took a keen interest in the furtherance of the objects of the Institute. He was for many years a member of council, and a Vice-president, and occupied the office of President during the years 1884 to 1886. Mr. Daglish, in addition to taking part in the business of the meetings, wrote the following papers:—

"The Relative Heating and Economic Values of Round and Small Coals," *Trans. N. E. Inst.*, 1856, vol. iv., page 283.

"Experiments on the Strength of Wire-ropes and Chains," *ibid.*, 1859, vol. vii., page 211.

"The Injurious Action on Iron in Upcast Shafts," *ibid.*, 1860, vol. viii., page 179.

"The Cause of the Loss of Strength in Iron Wire when Heated," *ibid.*, 1860, vol. viii., page 181.

"The Construction of Ventilating Furnaces," *ibid.*, 1861, vol. ix., page 131.

"The Various Modes of Ascertaining the Velocities of Currents of Air in Mines, in order to Determine the Quantities Circulating in a given Time," in conjunction with Mr. John Job Atkinson, *ibid.*, 1861, vol. x., page 207.

"The Destructive Action of Furnace Gases in Upcast Shafts," *ibid.*, 1861, vol. xi., page 19.

"The Donesthorpe, Firth and Ridley Coal-cutting Machine," in conjunction with Mr. Lindsay Wood, *ibid.*, 1863, vol. xii., page 63.

"The Ventilation of Underground Boilers," in conjunction with Mr. William Armstrong, *ibid.*, 1863, vol. xii., page 79.

"Paradoxes in the Ventilation of Mines," in conjunction with Mr. John Job Atkinson, *ibid.*, 1863, vol. xii., page 93.

"The Magnesian Limestone of Durham," in conjunction with Mr. George Baker Foster, *ibid.*, 1864, vol. xiii., page 205.

"Minerals and Salts found in Coal Pits," in conjunction with Mr. R. Calvert Clapham, *ibid.*, 1864, vol. xiii., page 219.

"Certain Improvements in the Construction of the Water-gauge," *Trans. N. E. Inst.*, 1865, vol. xv., page 103.

"The Broadbent Patent Safety-cage," *ibid.*, 1866, vol. xvi., page 33.

"The Conveyance of Coal Underground," *ibid.*, 1867, vol. xvi., page 53.

"A New Application of the Water-gauge for ascertaining the Pressure of the Ventilating Column in Mines," *ibid.*, 1867, vol. xvii., page 27.

"The Counter-balancing of Winding-engines," *ibid.*, 1871, vol. xx., page 205.

"Some Remarks on the Beds of Ironstone occurring in Lincolnshire," in conjunction with Mr. R. Howse, *ibid.*, 1874, vol. xxiv., page 23.

"The Application of Counter-balancing and Expansion to Winding-engines," *ibid.*, 1876, vol. xxv., page 201.

"An Improved Expansion Gearing for Winding-engines," *ibid.*, 1879, vol. xxix., page 3.

"Account of a Discharge of Lightning at Kimblesworth Colliery, on July 12th, 1880," *ibid.*, 1881, vol. xxx., page 129.

"Presidential Address," *ibid.*, 1886, vol. xxxv., page 223.

With a view of celebrating the fiftieth year of the reign of H.M. Queen Victoria, the council of The North of England Institute of Mining and Mechanical Engineers decided to hold a mining exhibition in 1887. As soon as the details of the scheme were published, it was taken up by the Mayor and many of the members of the Council of the city of Newcastle-upon-Tyne; and, at a public meeting, it was determined to expand the project and make it worthy of the metropolis of the North of England. Committees were appointed to carry out this extended scheme, and Mr. John Daglish was appointed chairman of the Executive Council. The Newcastle-upon-Tyne Royal Mining, Engineering and Industrial Exhibition, in which he took a keen interest, proved successful in every respect.

Mr. Daglish took a leading part in the inception and formation of The Institution of Mining Engineers. In his "Presidential Address"* to the members of The North of England Institute of Mining and Mechanical Engineers, on August 7th, 1886, he referred to the several schemes which had been mooted for the concentration of the various mining institutes. He considered that any attempt to amalgamate these institutes into one body would be difficult, if not impossible, but thought that a federation confined chiefly to the publication of their *Transactions* could be carried out to their general advantage. It would place the papers read at each institute in the hands of all mining engineers, and prevent repetition of papers, and duplication of

* *Trans. N. E. Inst.*, 1886, vol. xxxv., page 243.

investigations and experiments by committees on special subjects of general interest. An institute representing the whole of the mining science of Great Britain would be able to supply reliable information to the Government upon the real practical requirements of legislation, and would be a power to resist any proposed legislation contrary to the real interests of mine-owners and workmen. Mr. Daglish lived to see the successful realization of his ideas, and was a member of council and a Vice-president of The Institution of Mining Engineers until his death.

Mr. Daglish, for many years, was a governor of Armstrong College, Newcastle-upon-Tyne, and in 1890 he was appointed to the council, of which he remained an esteemed member until his death. He devoted considerable attention to its management during the later years of his life, and his name will always remain associated with Armstrong College owing to his munificent devise of property for its endowment. He founded the Daglish travelling fellowship in mining, in connection with that college, and the holders, after nomination by The North of England Institute of Mining and Mechanical Engineers, will be appointed by the special election board of the college.

He had also been a Fellow of the Geological Society, and a member of the Institution of Civil Engineers,* the Institution of Mechanical Engineers,† the Tyneside Naturalists' Field Club, the Berwickshire Naturalists' Field Club, the Newcastle Farmers' Club, the Scottish Arboricultural Society, the English Arboricultural Society, etc.

He acted as secretary of the Geological Section of the British Association for the Advancement of Science, at their meeting held in Newcastle-upon-Tyne in 1863, and as an honorary curator and a vice-president of the Natural History Society of Northumberland, Durham and Newcastle-upon-Tyne.

He died in London, on August 9th, 1906, and was interred five days later, in Cambo churchyard, Northumberland.

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* "The Sinking of Two Shafts at Marsden, for the Whitburn Coal Company," *Minutes of Proceedings of the Institution of Civil Engineers*, 1882, vol. lxxi., page 178.

† "The Mechanical Firing of Steam Boilers," *Proceedings of the Institution of Mechanical Engineers*, 1869, page 155.

THE NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

GENERAL MEETING,
HELD IN THE WOOD MEMORIAL HALL, NEWCASTLE-UPON-TYNE,
JUNE 8TH, 1907.

MR. J. H. MERIVALE, PRESIDENT, IN THE CHAIR.

The SECRETARY read the minutes of the last General Meeting and reported the proceedings of the Council at their meetings on May 25th and that day.

The SECRETARY read the balloting list for the election of officers for the year 1907-1908.

The following gentlemen were elected, having been previously nominated:—

MEMBERS—

Mr. JOHN ABEL CHAPMAN, Engineer, 56, Bewick Road, Gateshead-upon-Tyne.

Mr. FRANCIS HENRY LAMBTON CROUDACE, Colliery Manager, The Lodge, Lambton, Newcastle, New South Wales, Australia.

Mr. SYDNEY CROUDACE, Colliery Manager and Mining Engineer, New Lambton, Newcastle, New South Wales, Australia.

Mr. ROBERT WILLIAM HALL, Colliery Manager, Thrislington Colliery, West Cornforth, S.O., County Durham.

Mr. HAROLD HORWOOD-BARRETT, Mining and Consulting Engineer, 2, Park View Villas, Hove, Brighton.

Mr. CHARLES HOWSON, Colliery Manager, Harraton Colliery, Chester-le-Street.

Mr. DUDLEY JAMES INSKIPP, Mining Engineer, Grand Hotel, Bulawayo, Rhodesia, South Africa.

Mr. WILLIAM HENRY RAMSAY, Colliery Manager, Harperley Hall, Tantobie, S.O., County Durham.

Mr. ROBERT SMART, Assayer to the Yukon Government, White Horse, Yukon Territory, Canada.

Mr. William Teutenberg, Mining Engineer and Surveyor, Nenthead, Alston, S.O., Cumberland.

Mr. Errington Thompson, Metal-mine Manager, Weardale House, St. John's Chapel, S.O., County Durham.

Mr. Henry Walker, H.M. Inspector of Mines, Durham.

Mr. Henry Stevenson Willis, Colliery Manager, The Garth, Medomsley, S.O., County Durham.

Mr. William Wilson, Colliery Manager, Chilton Colliery, *via* Ferry Hill.

Associate Members—

Mr. Featherstone Fenwick, County Chambers, Newcastle-upon-Tyne.

Mr. James Kirkley, Cleadon Park, Cleadon, Sunderland.

Associates—

Mr. Philip Sidney Blunden, Under-manager, The Villas, Dean Bank, Ferry Hill Village, Ferry Hill.

Mr. George Elliott, Under-manager, Dinnington Colliery, Dudley, S.O., Northumberland.

Mr. George Tweddell, Back-overman, 51, Double Row, Seaton Delaval, S.O., Northumberland.

Students—

Mr. William Ernest Avery, Mining Student, Ravensworth Colliery Office, Low Fell, Gateshead-upon-Tyne.

Mr. John Brown, Mining Student, 4, Scotch Street, Whitehaven.

Mr. Thomas Watson, Jun., Mining Student, Rosebank, Darlington.

Mr. Hubert Watts, Mechanical Engineering Student, Cleveland House, North Shields.

DISCUSSION OF MR. R. CREMER'S PAPER ON "THE PNEUMATOGEN: THE SELF-GENERATING RESCUE-APPARATUS, COMPARED WITH OTHER TYPES."*

Mr. M. Walton Brown said that Mr. Fickler, of Gneisenau colliery, Westphalia, had stated that on April 17th, 1907, in company with Mr. von Harlessen and Mr. Giese, he had made a trial with the pneumatogen in the mine.† After the appliance had been in use for about 18 minutes, and as they were walking up a steep incline, it commenced to burn, and after great trouble he was able to prevent the flame from burning his clothes. It was found afterwards that heated peroxide of sodium and potassium had come into contact with an indiarubber ring, and caused it to take fire.

* *Trans. Inst. M. E.*, 1906, vol. xxxii., page 51.

† *Glückauf*, 1907, vol. xliii., page 524.

Mr. L. H. Hodgson said that the pneumatogen had been tried by Mr. W. E. Garforth in the Altofts-colliery experimental gallery with good results, but he thought that appliances of this kind would only be generally adopted in Great Britain when they were enforced by law.

Mr. R. Cremer (Leeds) wrote that Mr. von Harlessen, who was present at the incident, stated that the occurrence was due to an indiarubber jointing ring used in the pneumatogen at Gneisenau colliery; and that, in order to prevent such incidents, the indiarubber jointing material had been replaced by asbestos.

DISCUSSION OF MR. E. S. WOOD'S PAPER ON "SINKING THROUGH MAGNESIAN LIMESTONE AND YELLOW SAND BY THE FREEZING-PROCESS AT DAWDON COLLIERY, NEAR SEAHAM HARBOUR, COUNTY DURHAM."*

Mr. E. S. Wood said that during the previous discussion a question was asked about the lowest temperatures that had been observed for freezing shafts, and why temperatures down to −34·4° Cent. (−30° Fahr.) were not used. He asked the contractors to give their experience in the matter, and they stated that many experiments were carried out in Holland to produce lower temperatures in the freezing-tubes by the direct expansion of anhydrous ammonia or carbonic acid. Temperatures of −18° to −21° Cent. (−0·4° to −5·8° Fahr.) were adopted in order to keep the freezing-tubes sound, because long experience had shown that with lower temperatures the freezing-tubes in many instances were broken. In one case, the temperature of the brine was lowered to −30° Cent. (−22° Fahr.) because running water was circulating in the strata round the freezing-tubes; the water was frozen, but a high percentage of the pipes were broken. The plant used at Dawdon was capable of working at much lower temperatures, but it was advisable not to do this in order to save the freezing-tubes from being broken.

Mr. F. Coulson (Durham) said that the variation of the water in the pit as compared with the tides seemed somewhat remark-

* *Trans. Inst. M. E.*, 1906, vol. xxxii., page 551; and vol. xxxiii., page 197.

able, and perhaps Mr. Wood could give some theory to account for it. Did the water in the pit rise in exact proportion to the tide, or was there any difference in the speed of rising? They found that, with tides varying from 14 to 17 feet, the water in the pit only varied about 4 inches. He would like to know, if possible, how this variation of rise and fall in the water varied with the rise and fall of the barometer, if that had been observed. It seemed to him that the attraction that made the tides might have some influence on the large mass of water that was located in the Magnesian Limestone? It seemed curious that the rise and fall of the water in the shaft was the same before the sand-feeders were tapped, and that the sand-feeders rose to a level 4 feet higher than the Magnesian Limestone feeders. He would be glad to know the cause of this.

Mr. R. Sutcliffe (Barnsley) asked whether the rising water in the shaft might not be retarded by the inlet through the sand. If the spaces through which the water flowed were very contracted, it could not enter in anything like the proportion of the movement of the tides. Thus, 8 inches in 17 feet represented 1 in 25; and if the time when the tide was in did not permit of more water getting into the pit during that time, it could not rise so high. With respect to the attraction of the moon or sun causing the rise of water in the strata of the earth, the rise of the tide was almost enough to indicate that this was not so. There was not a tidal variation of 17 feet out at sea, but part of the 17 feet would be caused by the land-resistance, causing an excessive rise through the momentum of the water set in motion by the tides, and the amount of water getting into the shaft would depend on the openings in the stone to admit it. He did not see how the attraction of the sun or moon would affect the rise of the water, without affecting the barometer much more, which it had not done.

Mr. M. Walton Brown said it occurred to him that the variation was not altogether due to the tide, but might be due to a variation of the hydraulic gradient, caused by the water in the strata being dammed up by the rising tide, and being released by the falling tide. This would occur if the level of the water in the shaft corresponded with the level of low water.

Mr. F. Coulson said that the water in the shaft continued to rise for 3 hours after the turn of the tide, and it appeared to him that on the tide falling, the shaft being only a short distance from the sea, the water ought to start to fall again, but it did not do so. The highest rises of water in the shaft occurred with a low barometer. There was a well at Sunderland, some distance from the sea, where the level of the water in the sand, about 45 feet above sea-level, used to rise and fall 4 inches with the tides. It might be caused by tides backing the water, but he did not see how this could take place without stopping the outlet.

Mr. E. S. Wood said that the rise and fall of the water in the shaft was carefully recorded; and, as Mr. Coulson had pointed out, it was at its highest about 3 hours after the tide was at its height. It gradually followed the rise and fall of the tide. The saltness of the water, when they were pumping, seemed to indicate that some of the gullets were connected directly with the sea, and that would account for the tidal variations of level. The fact of the water rising above the previous water-level, on the bore-holes passing through the Magnesian Limestone into the sand, might be owing to the outcrop of the sand, at the surface inland, being at a higher level than the water in the Magnesian Limestone on the coast. In that case, there was a flow of water from the higher level inland towards the sea, and the outlet at the shaft would naturally cause the water from the sand and below the Marl Slates to rise.

The President (Mr. J. H. Merivale) said that the points raised in the discussion were interesting, and Mr. Coulson might find that the forces which originated the tides would necessarily tend to cause similar tides in the water contained in the earth's crust.

Mr. Richard Harle's paper on the "Treatment of Dust in Mines, Aboveground and Belowground" was read as follows:—

TREATMENT OF DUST IN MINES, ABOVEGROUND AND BELOWGROUND.*

By RICHARD HARLE.

The recent explosions in mines undoubtedly confirm the opinion that "where there is dust there is danger," they prove that newly-made dust can easily be ignited with explosive violence, and they show the danger of using naked lights in dusty mines.

It is admitted that dust-accumulations are derived from the tops of loaded tubs in transit out-bye, on meeting the intake air; by the running of empty tubs in-bye: and dust caused by screening aboveground finds its way into the mine, and is deposited on all timbers, pillarings, floors and other places on the main roads.

The writer has been continually reminded of the destructive effects of explosions, and has seen so much of the dangers of dust, that he has endeavoured, in respect equally of its removal, its prevention and watering, to improve and get rid of the danger by a new system of damping and spraying, at the places above and belowground, where it is made.

With the view of preventing accumulations, the writer has previously described a method of dealing with dust by automatically sprinkling the tops of loaded tubs, before leaving the in-bye stations.† That arrangement has been in use at Browney and South Brancepeth collieries for a number of years, and it has done much to prevent accumulations of dust on the road-ways, along which the coal is conveyed.

Another mode has recently been perfected to deal with the dust-danger aboveground and belowground: it can be applied at any place wherever fine water-spraying is required for damping or cooling; and, by its means, the damped dust is arrested and kept secure in the tubs during transit on the main roads from the in-bye landings to the shaft.

* Application for British patent, February 13th, 1907, No. 3,612.

† "Automatic Sprayer for Preventing Accumulations of Dust in Mines," by Mr. R. Harle, *Trans. Inst. M. E.*, 1899, vol. xviii., page 113.

The new arrangement provides wet zones of misty spray on the wagonways, traversed by the tubs: dampens both full and empty tubs, and moistens the dust so as to ensure its removal out of the pit; and the air, periodically saturated as it goes in-bye, deposits sufficient moisture to damp any other dust.

The distributors can be fixed to stand-pipes and applied to screens, coal-tipplers, coal-conveyers, coal-drawing shafts, or other places aboveground, to moisten the dust at any point where it arises, and to prevent it from getting into the mine.

The apparatus can be fixed at any intervening space on underground roadways, at junctions, at rope-offtakes, and where one haulage-road joins another, so as to isolate each district, and at or near the shafts or in-bye stations. The water is delivered at a high pressure, and is pulverized by the action of the distributors, for the precipitation of dust.

The new apparatus works automatically, and can be applied to both main-and-tail-rope or endless-rope systems of haulage. The spraying continues during working hours, so long as the tubs are travelling, and ceases at the end of the shift, when no coal is in transit.

The arrangement consists of a small pump, about 2 inches in diameter and 6 inches stroke, with gearing and attachments, capable of delivering sufficient water, at a pressure of about 100 pounds per square inch, to a spray-pipe, $\frac{3}{4}$ inch in diameter, placed in the gallery, and fitted with nozzles and distributors to pulverize and distribute the water equally over the surrounding surfaces. The approximate quantity of water pulverized from each nozzle and distributor is about 1 quart per minute, under a pressure of 100 pounds per square inch; and it can be varied according to the pressure, and to the size of the hole in the nozzle.

On the roadways where coal is conveyed by main-and-tail-rope haulage (figs. 1, 2 and 3, plate ix.), the drum or friction-wheel, A, is actuated preferably by the movement of the tail-haulage rope, B, arranged by pulleys, C and D, to pass over or under the wheel, A, at a point near to the pump, G, gear-wheels, E and F, and water-tank, H. The water-pressure is controlled by a valve, J, on the delivery-pipe, K; and the water can be delivered at a pressure of 100 pounds per square inch (figs. 4, 5 and 6, plate ix.). The delivery pipe is fitted with nozzles, L,

arranged to produce a fine spray, both in-bye and out-bye. The wet zone can be extended to a length of 150 feet or more in either direction, by extending the spraying or outlet pipe.

The method of spraying where endless-rope haulage is in use is shown in figs. 7, 8 and 9 (plate ix.). In this case, a suitable length of rope or chain, A, is arranged on the tub-way, and carried round a drum or sheave, B. The apparatus is controlled and kept in motion by the tubs as they pass over the chain, thereby working the shafting and gearing in connection with the pump, C, and keeps a continuous spray in the gallery as the tubs pass along. Water is stored in the tank, D; and forced by the pump, C, through the pipe, E, and regulating-valve, F, to the pipe, G, fitted with nozzles, H, producing a misty spray, both in-bye and out-bye (figs. 10, 11 and 12, plate ix.). The wet zone can be extended to a length of 150 feet or more in either direction, by lengthening the spray or outlet pipe.

The author has designed two patterns of nozzles and water distributors for attachment to the pipes of the automatic water-spraying apparatus. In the first design, the nozzle, A, made of pipe $\frac{3}{4}$ inch in diameter, is screwed into the water-supply pipe; B, is a barrel or drum, fitted with blades or vanes, C, and carried by the bridle or supporting straps, D, attached to the nozzle by the screw or rivet, E (figs. 13 and 14, plate ix.) The second design is similar in every respect, except that the drum or barrel, B, is fitted with a diverting ring, F, which materially assists in the formation of the water-spray (figs. 15 and 16, plate ix.). The dimensions of the nozzle and of the distributor may be varied to suit any diameter of pipe or flow of water.

The working of the machines show the following advantages:—

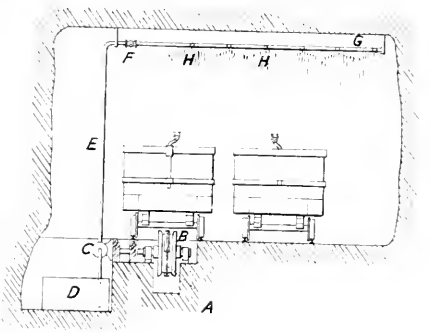
(1) Sprayed and well-watered zones, over long distances, are produced at any suitable place in the galleries or main roads.

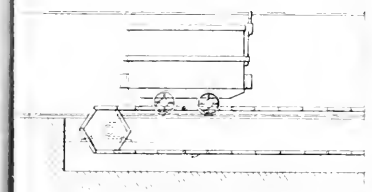
(2) Each district can be isolated; and, in case of an explosion of gas, damage to roadways and air-crossings will be prevented, the loss of life will be greatly minimized, and the entry of fresh air into the mine will be facilitated.

(3) The dust, kept moist and secure in its transit in tubs on the wagonways, is carried out of the mine, just as in damp mines, where no trace of dust is found.

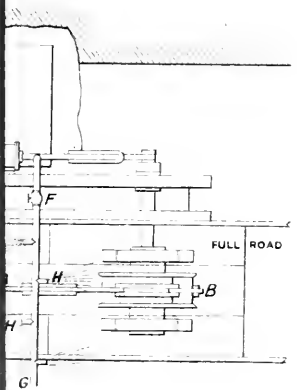
ARRANGEMENT FOR ENDLESS-ROPE HAULAGE.

FIG 9.—END ELEVATION.





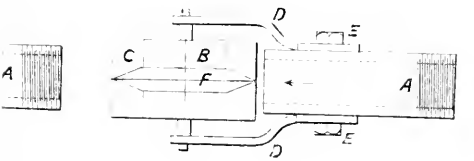
0.—PLAN.



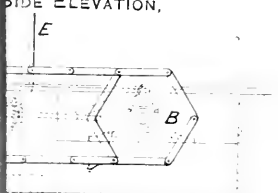
AND WATER-DISTRIBUTOR.

SECOND DESIGN.

FIG. 15.—PLAN.

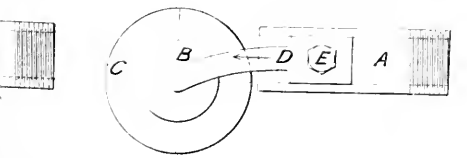


SIDE ELEVATION,



N.

FIG. 16.—SIDE ELEVATION.

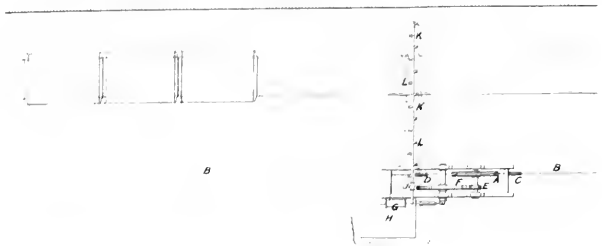


Scale. 3 Inches to 1 Inch.

Newcastle upon Tyne

ARRANGEMENT FOR MAIN-AND-TAIL-ROPE HAULAGE

FIG. 1.—PLAN



Scale, 6 Feet to 1 Inch.

FIG. 2. SIDE ELEVATION

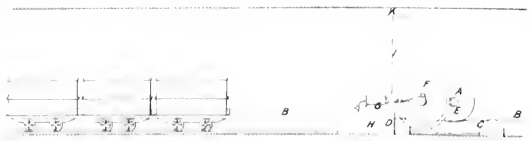


FIG. 3.—END ELEVATION

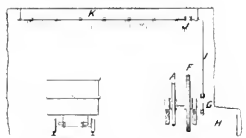
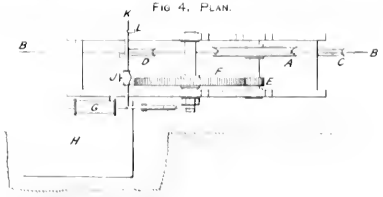


FIG. 4. PLAN.



Scale, 3 Feet to 1 Inch.

FIG. 5. SIDE ELEVATION

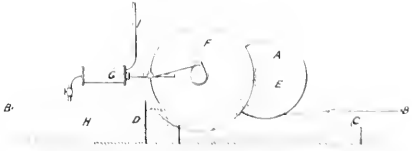
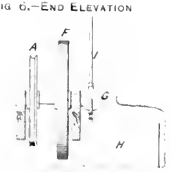


FIG. 6.—END ELEVATION



ARRANGEMENT FOR ENDLESS ROPE HAULAGE.

FIG. 7.—PLAN

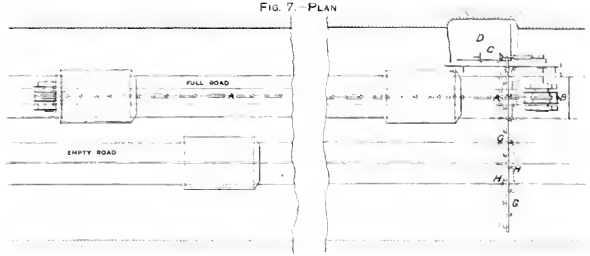
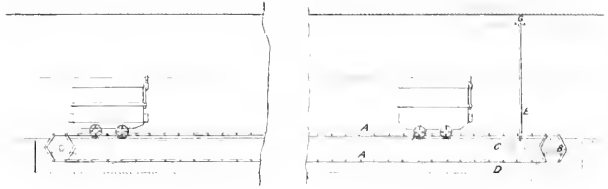


FIG. 8.—SIDE ELEVATION



Scale, 6 Feet to 1 Inch.

FIG. 9.—END ELEVATION.

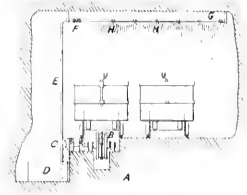
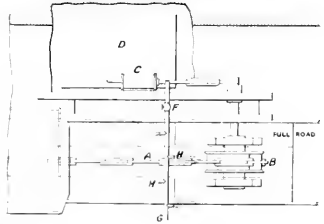


FIG. 10.—PLAN



Scale, 3 Feet to 1 Inch.

FIG. 11.—SIDE ELEVATION.

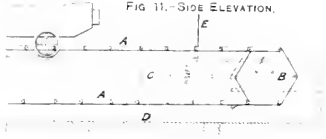
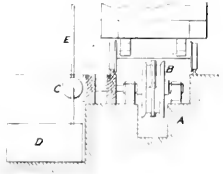


FIG. 12.—END ELEVATION



NOZZLE AND WATER-DISTRIBUTOR.

FIRST DESIGN

FIG. 13.—PLAN.

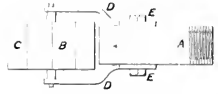
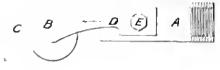


FIG. 14 SIDE ELEVATION



SECOND DESIGN.

FIG. 15. PLAN

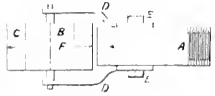
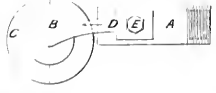


FIG. 16. SIDE ELEVATION.



Scale, 3 Inches to 1 Inch

REFERENCE.

FLOW OF WATER.

(4) There is no excessive watering or wetting of coal.

(5) It obviates the danger of dust accumulating in the galleries, and prevents it from being carried in-bye to the face-workings.

(6) The distributors prevent, when placed aboveground, the removal of dust, which is found at screens and other places aboveground, and prevent it from moving about the shaft and passing down the pit.

(7) There is no waste of coal or dust in screening, or in conveying it to the coke-ovens; and explosions are prevented in coke-ovens and other places aboveground.

(8) The cost of upkeep and supervision is almost *nil*, and the system will save labour and cleaning of roads.

(9) It requires little, if any, extra space to fit it on the main roads.

(10) The coal-dust is arrested at the source, and absolute safety is afforded against sweeping explosions.

The President (Mr. J. H. Merivale) said that one of the most important problems in connection with the question of watering was the effect of damping the roads, as it might cause heaving and other injury in the mine. It seemed to him that the arrangement proposed by Mr. Harle would very largely overcome the difficulties, as, instead of damping the floor, it would simply damp the coal on the top of the tubs. The greater part, probably the whole, of the dust distributed on haulage-roads must necessarily come from the sets of tubs, or be blown down the shaft from the screens; and, by damping the coal on the sets of tubs, the dust would be prevented from accumulating on the ground and causing those difficulties, which arose from the use of water on haulage-roads.

Mr. E. S. Wood (Dawdon colliery) endorsed what had been said by the President about the use of water-sprays in mines, as, in some mines in the county of Durham especially, undue watering of haulage-roads would materially affect both the roofs and sides; but, at the same time, watering seemed to be a step in the right direction. There could be no doubt that coal-dust was a source of great danger in coal-mines. The danger might

be reduced by providing proper tubs, with absolutely tight bottoms, so that coal-dust could not get out on to the haulage-roads, upon which the tubs were travelling. And further, the provision of distinct and separate wet zones in the different districts might, in the case of an explosion, absolutely prevent the explosion from being carried over the wet zone. The apparatus described in Mr. Harle's paper might be adapted to a certain extent to making such a zone immediately under the water-spray. A distance of 450 to 600 feet in the vicinity of the water-spray might be arched and made absolutely wet without damaging the floor of the seam and causing heaving, and it would obviate the probability of an explosion passing beyond that wetted area. These watering arrangements could be placed at the different engine-landings, and at some collieries they might be placed near the working-places. He suggested further that portions of the haulage-roads should be converted into absolutely wet zones.

Mr. C. C. Leach (Seghill colliery) said that he had sent samples of dust from haulage-roads for analysis, and he was asked why coal-dust had not been sent. This dust had been actually collected by himself from the roofs and sides of haulage-roads. He thought that it chiefly consisted of clay and shale, with a little coal-dust. He thought that water-spraying could be done, without special machinery; and water under pressure from the surface would make a more efficient spray than would be produced by a small pump. He did not quite agree with Mr. Wood that haulage-roads could be sprayed without injury. Watering would be chiefly required, in wide places, at the junctions of haulage-roads, and the effects would sometimes be very injurious.

Mr. T. C. Futers (Newcastle-upon-Tyne) said that Mr. Harle claimed that his arrangement would prevent the accumulation of dust on the heapstead. The apparatus would simply spray the top of each tub as it passed underneath it, and consequently he did not see how the coal inside the tub would be sufficiently damped so as to prevent the dust from rising, especially on the jigging-screens, where it would cloud the air and finally pass down the shaft.

Mr. C. H. Steavenson (Redheugh colliery) said that the arrangement was very ingenious, and the members were indebted

to Mr. Harle for bringing it to their notice; but he did not think that watering was the solution of the difficulty. He had found that the watering of roadways had a most injurious effect upon them: and, although that method suited some collieries, it was necessary to discover some means of removing the dust without watering it. It was possible that it might be enacted by Parliament that dust should be removed by brushing; but it occurred to him that it might be possible to remove dust from mines by means of suction-machines, similar to those used for cleaning carpets.

Mr. C. C. Leach (Seghill colliery) asked what was the cost of cleaning a square yard of carpet, and then only a few ounces of dust would be removed.

Mr. T. C. Futers said that such an arrangement had already been successfully applied to a screening-plant: a series of suction-pipes were applied to the jigging-screens, and all the dust was withdrawn from the screens and so prevented from going down the pit.

Mr. R. Sutcliffe (Barnsley) said that the removal of dust by brushing in a strong current of air would result in the dust being carried in large quantities into the working-places, and that would be increasing the danger.

Mr. F. Coulson (Durham) said that if the water-spray was used in a length of haulage-road, arched with brickwork, so as to prevent crushing owing to the action of the water, and the space kept damp, it would stop any coal-dust explosion; but a severe gas explosion would be carried through any moderate length of damp ground. In any case, a wet zone would not prevent the after-damp from passing from the vicinity of the actual explosion into other districts. He suggested that tub-grease might render coal-dust more explosive, and pointed out that on an ordinary haulage-road hundreds of tons of tub-grease were used and ground and mixed with the coal-dust. He moved a vote of thanks to Mr. Harle for his interesting paper.

Mr. C. C. Leach seconded the resolution, which was cordially adopted.

Mr. R. HARLE, replying to the discussion, wrote that the sprayers were being efficiently used at the collieries under his charge, and it was found that no injury was done to the roadways by the dewy spraying. No walling or arching was required in the dustless zone. His best reply to all other questions and criticism on the performance of the invention would be by a practical demonstration of the working of the apparatus; and he would be very pleased to show it in use to any of the members.

THE NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

EXCURSION MEETING,
HELD AT SUNDERLAND, JUNE 6TH, 1907.

C PIT, MONKWEARMOUTH.

The freezing method of sinking the new or C pit has been adopted, so as to avoid any chance of disturbing the A and B pits, at the adjoining Wearmouth Colliery, which have been in operation for seventy years. These pits are sunk to the Hutton seam, at a depth of 1,723 feet; and the new or C pit will be sunk to the Harvey seam, at a depth of 1,902 feet. The C pit, 18 feet in diameter, is now sunk to a depth of 117 feet; but sinking operations have been suspended until the strata are frozen. For this purpose, 28 holes, 360 feet deep, have been bored round the circumference of the shaft, in a circle, 28 feet in diameter—three boring-machines, three steam-winches, and three steam-pumps being employed. Boring commenced on October 8th, 1906, and was completed on March 15th, 1907: the total boring of 9,725 feet being thus completed in 128 days, or an average of 25 feet per day.

Hollow rods, 2 inches in diameter and in 16 feet lengths, were employed, the weight-rod being 16 cwts. The chisels varied from 7 inches to 12¼ inches in diameter, and weighed from ½ cwt. to 1½ cwts. The steam-pumps forced 4,000 gallons of water through each set of boring-rods per hour, the pressure at the pumps being 75 pounds per square inch. As an example of the speed of boring, one hole was bored 100 feet by means of chisels, 12¼ inches in diameter, and the hole was lined with tubes 11 inches in diameter; it was then bored 90 feet deeper with chisels 10¼ inches in diameter, and lined to this depth with tubes 9¼ inches in diameter; and the remaining 170 feet were bored with chisels 7¼ inches in diameter, and the full depth was lined with tubes 6¼ inches in diameter, the total time occupied being 10

days. Each freezing-pipe comprises an upper tube, 240 feet long and 5 inches in diameter; an expansion-piece; and the lower tube, 4 inches in diameter and 120 feet long: the double nipple being placed at a depth of 75 feet.* The central pipe, 1 inch in diameter, delivers the brine 3 feet above the bottom of the freezing-pipe.

The refrigerating agent is anhydrous ammonia, and the brine is a 28-per-cent. solution of chloride of magnesium. Freezing commenced on April 10th, 1907. On June 6th, 1907, the temperature of the brine entering the pit was 2° Fahr. (−16·6° Cent.), and returning from the pit, 9·5° Fahr. (−12·5° Cent.). The cooling water entered the condensers at a temperature of 54·5° Fahr. (12·5° Cent.), and left at 61·7° Fahr. (16·5° Cent.). The circulation of brine is about 150 gallons per minute, and the quantity of cooling water is approximately 200 gallons per minute. The pressure of the ammonia in the condensers is 9·8 atmospheres, and in the refrigerators, 0·6 atmosphere.

* *Trans. Inst. M. E.*, 1906, vol. xxxii., page 576, plate xxviii., fig. 8.

MEMOIR OF SIR LOWTHIAN BELL, BART.

Sir Lowthian Bell, Bart., who was born in Newcastle-upon-Tyne in 1816, was a son of Mr. Thomas Bell, a member of the wellknown firm of Messrs. Losh, Wilson and Bell, whose ironworks at Walker, near Newcastle-upon-Tyne, were then among the largest of the kind in the country; his mother being a daughter of Mr. Isaac Lowthian, of Newbiggin, near Carlisle.

Sir Lowthian Bell received his early education at Dr. Bruce's academy in his native city, and afterwards became a student at Edinburgh University, concluding his studies at the University of the Sorbonne in Paris.

At the time when his education was considered complete, the Walker Ironworks were in the full tide of prosperity, and Sir Lowthian was appointed to the responsible position of manager. In 1850, he, together with the late Mr. Hugh Lee Pattinson and Mr. R. B. Bowman, established large chemical works at Washington, the late Mr. R. S. Newall afterwards becoming a member of the firm. In 1872, Sir Lowthian severed his connection with the Washington Chemical Works, and devoted all his time and attention to the great works which he and his brothers had founded on the banks of the Tees, and with which his name will ever be honourably associated. Mr. Vaughan, who made the discovery of the Cleveland ironstone-beds, which laid the foundation of the great iron-trade now established in the Cleveland district, had been associated with Sir Lowthian Bell at the ironworks of Messrs. Losh, Wilson and Bell, but now severed his connection with the firm, shortly before 1850, and commenced for himself near the Tees. His discovery rapidly attracted to the district some of the most energetic men which this country has produced, Sir Lowthian Bell, and his brothers Thomas and John, being among the early pioneers in the Cleveland iron-trade. In 1852, they secured about 30 acres of land at Port Clarence, on the north side of the Tees, opposite Middlesbrough, and there established the Clarence Ironworks; and from that time the wellknown firm of Messrs. Bell Brothers has held a high and honourable position in connection with the iron-trade of this country. The original site of 30 acres has been added to, and now the company owns a site of about 200 acres in extent. Ironstone-mines were opened by the firm

near Saltburn-by-the-Sea, Normanby, and Skelton-in-Cleveland, and coal-royalties in Durham were secured and worked by them, and for many years past the company has given employment to about 6,000 workmen. Every improvement in the mode of production of iron was adopted by the firm, the result being that the Clarence works have been regarded among iron-manufacturers as models of perfection. The small blast-furnaces originally erected were replaced by large structures, built on the most improved principles, and the firm was the first in Cleveland to adopt the plan of utilizing the waste-gases which escaped from the furnaces.

The great difficulty in the smelting of Cleveland ores in regard to steel is the high percentage of phosphorus (1·8 to 2·0 per cent.) contained in the cast-iron which they yield; yet Middlesbrough, largely as the results of experiments carried on under Sir Lowthian's directions, at a cost, it is said, of between £40,000 and £50,000, produces steel-rails in which the percentage is reduced to 0·07 or less. Many thousand tons of such basic-steel rails have been laid on the North-eastern Railway, and the careful records kept of their behaviour convinced Sir Lowthian that neither in loss of weight by wear nor in the number of breakages did they give any grounds for complaint In connection with rails, it is interesting to note, as an illustration of the advances made during his exceptionally long and active life, that he remembered wooden rails in use on the tramroads by which coal was brought down to the river Tees.

To Messrs. Bell Brothers, Middlesbrough is also indebted for the development of the salt industry. In 1862, Messrs. Bolckow and Vaughan, when boring for water for their works on the south side of the Tees, proved a bed of salt at a depth of 1,313 feet; but apparently no use was then made of so important a discovery. Ten years later, Messrs. Bell Brothers had a boring made at Port Clarence, on the north side of the Tees, and, at a depth of 1,127 feet, found a stratum of salt, which is about 100 feet thick; and in the year 1882 commenced working this valuable bed of rock-salt. In 1888, they disposed of their salt-works to the Salt Union, Limited; and in the year 1884, erected a soda-works, where alkali containing 58 per cent. of causticity was manufactured by the ammonia process, invented by Mr. Schlœsing, the eminent French chemist.

Sir Lowthian was ever ready to give a trial to any suggested improvement in connection with the manufacture of iron; and the high reputation which he deservedly held as a chemist and iron-manufacturer, caused him to be regarded as one of the greatest authorities on the subject in the North of England. His reputation as an authority on all matters connected with mineralogy and metallurgy was not confined to this country, for he was equally looked up to in the United States of America and in many European countries. At the meeting of the British Association for the Advancement of Science, held in Newcastle-upon-Tyne in 1863, he read a paper "On the Manufacture of Iron in connexion with the Northumberland and Durham Coal-field;"* and at a meeting of the Iron and Steel Institute, held at Middlesbrough in 1871, he read a most valuable paper on the "Chemical Phenomena of Iron Smelting."† The latter paper was frequently added to, as its author made more experiments; until it at last appeared in the form of a bulky volume, which came to be regarded as a standard authority in the iron-trade, not only in this country, but also in Europe and America. The book has been translated into the German, French, and Swedish languages. Another book to which Sir Lowthian Bell made valuable contributions is *The Industrial Resources of the Tyne, Wear and Tees* (1863).

In 1854, Sir Lowthian became a member of The North of England Institute of Mining and Mechanical Engineers; he was elected to the Council in 1865, in the following year became one of its Vice-Presidents, and, in 1886, was elected President. He was one of the founders of the Iron and Steel Institute, and followed Sir Henry Bessemer in the Presidential Chair in 1874. He was a Fellow of the Royal Society and of the Chemical Society of London, a member of the Society of Arts and of the British Association for the Advancement of Science, and a Member of The Institution of Civil Engineers. He was a member of the Institution of Mechanical Engineers, and was elected President of that Institution in 1884; and had also been a member and President of the Society of Chemical Industry.

* *Report of the Thirty-third Meeting of the British Association for the Advancement of Science, held at Newcastle-upon-Tyne*, 1863, page 730.

† *The Journal of the Iron and Steel Institute*, 1871, vol. i., pages 85 and 277; vol. ii., pages 67 and 277; and 1872, vol. i., page 1.

For his scientific work he was honoured by many of the learned societies of Europe and America. When the Bessemer Gold Medal was instituted by the Iron and Steel Institute in 1874, Sir Lowthian was the recipient. On the presentation to the Royal Society of his paper "On some supposed changes Basaltic Veins have suffered during their passage through and contact with Stratified Rocks, and on the manner in which these Rocks have been affected by the heated Basaltic,"* he was elected a Fellow on May 27th, 1875. In 1885, on the advice of Mr. Gladstone, a baronetcy was conferred upon him in recognition of his great services to the State. From The Institution of Civil Engineers he received the George Stephenson Medal in 1900, and in 1891 the Howard Quinquennial Prize, which is awarded periodically to the author of a treatise on iron. In 1895, he received at the hands of the King (then Prince of Wales) the Albert Medal of the Society of Arts, in recognition of the services rendered to arts, manufactures, and commerce by his metallurgical researches. From the French Government he received the decoration of the Legion of Honour. He was a D.C.L. of Durham University, an LL.D. of the Universities of Edinburgh and Dublin, and a D.Sc. of Leeds University.

With his chief interest centred directly on the manufacture of iron, and as one of the original founders of the Iron and Steel Institute, it was only natural that after its birth he should favour it with the bulk of his writings; yet, in the early days of The North of England Institute of Mining and Mechanical Engineers, he devoted considerable time to its welfare and success, and took an active part in the discussion of all papers read bearing upon any subject upon which he could throw enlightment.

An explosion took place at Hetton Colliery on December 20th, 1860, in the boiler-flues of one of the engines near the bottom of the downcast shaft. The force of the explosion blew down an air-crossing over the main wagonway, and then penetrated inbye, with the most serious results, 22 persons, 9 horses, and 56 ponies being killed, as well as considerable damage being done to the pits. Sir Lowthian, along with Dr. Richardson, two of the leading scientific and manufacturing chemists of the district, were called in, with a view of ascertaining if they could by their chemical knowledge account satisfactorily for so extra-

* *Proceedings of the Royal Society of London*, 1875, vol. xxiii., page 243.

ordinary an explosion, and the conclusion arrived at was that the disaster was due to the presence of underground boilers, the accident being caused entirely by the damping of the fire with a large quantity of coal; and the dampers having been too closely put down, the distillation of gas from these coals oozing through underneath the dampers filled the flues with explosive gas because too little air was allowed to pass to sweep it away as it was generated.

In 1861, he was appointed, together with the late Mr. Nicholas Wood and the late Mr. John Tom Woodhouse, by the Council of The North of England Institute of Mining and Mechanical Engineers, to give evidence before the Commission appointed by the Home Office to enquire into the constitution and management of the University of Durham, with a view to inducing the authorities to incorporate with the University a practical Mining College; and in 1868 the Council again appointed him with the late Sir George Elliot (first baronet) and the late Mr. William Cochrane, to give evidence before the Parliamentary committee then sitting to consider the advisability and the best means of initiating and extending technical education throughout the district.

On the founding of the Durham College of Science (now Armstrong College) in Newcastle-upon-Tyne in the year 1871, he was appointed a Governor, and continued to serve on that body throughout his long life. From the first he took a very great interest in technical and scientific education, and remained to the last a generous friend of the College, one of his latest benefactions being a donation of £4,500 to defray the entire cost of the building of the main tower, which bears his name. His son, Sir Hugh Bell, Bart., presented to the library of the College a large collection of valuable books from his father's library.

He was a director of the North-eastern Railway Company from the year 1865 until his death, and for many years was vice-chairman, and chairman of the locomotive committee.

Among other labours, he served on the Royal Commission on the Depression of Trade, and formed one of the Commission which in 1866 proceeded to Vienna to negotiate free trade with Austria-Hungary. He also gave evidence before the Parliamentary committee on the coal question in 1873. He acted as judge at the Philadelphia Exhibition of 1876, and as a juror at the Paris Exhibitions of 1878 and 1889. He served as a

member of the Executive Council of the International Inventions Exhibition, London, in 1885, and at several other great British and foreign exhibitions. He was a member of the Council of the Imperial Institute (acting as Vice-Chairman of the Organizing Committee of that body), the appointment having been made by His Majesty the King (then Prince of Wales) in 1888.

He was a justice of peace for the county of Durham, and deputy-lieutenant and high-sheriff in 1884. He was also a justice of the peace for the North Riding of Yorkshire, and for the city of Newcastle-upon-Tyne.

As a large employer of labour, Sir Lowthian Bell was a keen observer of, and took a warm interest in, everything relating to the welfare of his workmen. At an early stage of the general strike of miners in the County of Durham in 1879, as head of the firm of Messrs. Bell Brothers he announced his willingness to accept arbitration in the difficulty with their workpeople, this proposal being readily accepted. The men returned to work, and shortly afterwards mining operations throughout the entire county were resumed.

Sir Lowthian always took a deep interest in the prosperity of his native city. He entered the Town Council in 1850, was elected to the ancient and honourable office of sheriff in 1851; and on November 9th, 1854, he was elected mayor. The chief events of his mayoralty were the laying of the foundation-stone of the Town Hall buildings, and the opening of a new wing at the Royal Infirmary. In October, 1859, Alderman Joseph Lamb died, and Sir Lowthian was then unanimously elected an alderman, and retained his seat on the Council until November 9th, 1880.

The invitation to the British Association for the Advancement of Science to hold its meeting in Newcastle-upon-Tyne in 1863 having been accepted, it was necessary that the Council should elect to the post of chief magistrate a gentleman who, by his ability and learning, was qualified to welcome the members of so learned an Association to the metropolis of the north, and the choice of the Council fell a second time upon Sir Lowthian. Not only did Sir Lowthian worthily maintain the reputation of the town for hospitality, but he also, as before mentioned, read a valuable paper to the members of the Association.

Throughout his life Sir Lowthian took a fair share of interest in politics, supporting the moderate Liberals until the

rupture in the party on the Home Rule question, when he joined the Unionists. His connection with Tyneside and the county of Durham, in the industrial prosperity of which he was so deeply concerned, led to his being selected in 1868 by the Liberal party as a fellow-candidate with Sir Hedworth Williamson for North Durham, in the place of Mr. Shafto, one of the retiring members. The Conservatives were represented by the late Sir George Elliot (first baronet). A long and well-fought contest was brought to a termination in November, 1868, the defeated candidate being Sir Lowthian. The next general election took place in February, 1874, and Sir H. Williamson, not being willing to fight another contested election, retired, and the Liberal party brought forward Sir Lowthian and the late Sir C. M. Palmer in opposition to Sir George Elliot and Mr. R. L. Pemberton. The polling resulted in the defeat of the Conservatives. For only a brief time did Sir Lowthian Bell and Sir C. M. Palmer enjoy their victory, as a petition was lodged by the Conservative candidates, and resulted in their being unseated on the ground of general intimidation by agents. Sir Lowthian contested the Hartlepools in 1875, and was returned at the head of the poll. For five years Sir Lowthian enjoyed the honour of a seat in the House of Commons, and rendered great service in committees, his great knowledge of the commercial industries of the country being invaluable. He was ousted from his seat at the general election in April, 1880.

Sir Lowthian Bell, in 1842, married the second daughter of the late Mr. Hugh Lee Pattinson, and had a family of two sons and three daughters. For many years he resided in Newcastle-upon-Tyne, removing to Washington Hall on the establishment of the chemical works at Washington. On the severance of his connection with the Washington Chemical Company, he took up his residence at Rounton Grange, near Northallerton.

He was one of the founders of The Institution of Mining Engineers, and was elected President at the annual general meeting held at Birmingham on September 14th, 1904, but died at his residence, Rounton Grange, Northallerton, on December 21st of the same year, in his eighty-ninth year, and was buried at Rounton two days later in the presence of the members of his family and a large gathering, comprising representatives of all classes. At a memorial service held simultaneously at Middlesbrough, the Dean of Durham delivered an address in which he

pointed out that Sir Lowthian's life had been one of the strenuous exertion of great powers ever grappling and successfully combating with the difficult problems which have revolutionized the engineering world during his long life, giving life-long denial to the statement that Englishmen can always "muddle through," for he based all his action and success on clearly-ascertained knowledge.

Among the many expressions of sympathy conveyed to the family of the late Sir Lowthian Bell, was one from the King, who was pleased to say that he had a great respect for Sir Lowthian, and always looked upon him as a very distinguished man. The Council of The Institution of Mining Engineers passed the following resolution:—

> The Council have received with the deepest regret intimation of the death of their esteemed President and colleague, Sir Lowthian Bell, Bart., one of the founders of the Institution, who presided at the initial meeting held in London on June 6th, 1888, and they have conveyed to Sir Hugh Bell, Bart., and the family of Sir Lowthian Bell an expression of sincere sympathy with them in their bereavement. It is impossible to estimate the value of the services that Sir Lowthian Bell rendered to The Institution of Mining Engineers in promoting its objects, and in devoting his time and energies to the advancement of the Institution.

He is succeeded in the title by his eldest son, Hugh, who also takes his late father's position as managing partner of the firm of Messrs. Bell Brothers, Limited.

APPENDICES.

I.—NOTES OF PAPERS ON THE WORKING OF MINES, METALLURGY, ETC., FROM THE TRANSACTIONS OF COLONIAL AND FOREIGN SOCIETIES AND COLONIAL AND FOREIGN PUBLICATIONS.

CUTANEOUS INFECTIVITY OF ANKYLOSTOMIASIS.

L'Infezione da Anchilostoma per la Via cutanea. *By* GINO PIERI. *Atti della Reale Accademia dei Lincei*, 1905, *series* 5, *Rendiconti, vol. xiv., pages* 547-554.

Premising that he has been at work on this important subject since 1901, the author gives an account of the experiments which he has carried out in the Laboratory of Comparative Anatomy directed by Prof. B. Grassi.

On December 4th, 1901, he placed on his own skin, and on that of Drs. B. Grassi and Noé, several thousands of larvæ of *Ankylostoma*, but the results are described as inconclusive. Further experiments, in the course of 1903, were purely negative in regard to the transmission of the infection through the skin. But, as a result of the experiments made on dogs by the author in the course of 1905, and of the evidence accumulated by other experimenters, he admits unreservedly that ankylostomiasis can be transmitted through the skin by mature larvæ. Nevertheless, he regards ingestion through the mouth as the principal mode of infection, and adduces the evidence in favour of this contention, as against the contrary opinion upheld by Drs. Calmette, Breton and Liebmann (that infection through the skin is the chief cause of the trouble).

He also lays stress on the following points: (1) Not all the larvæ that come into contact with the skin pierce through it; (2) not all the larvæ that do pierce through the skin actually reach the intestine; and (3) the experiments on animals show that the older the subject of the experiment is, the less easily, rapidly, and abundantly, does infection through the skin take place.

L. L. B.

MINING LEGISLATION IN HOLLAND.

Note sur la Législation Minérale des Pays-Bas. *By* J. G. BOUSQUET. *Annales des Mines*, 1905, *series* 10, *Mémoires, vol. vii., pages* 123-140.

Until recently the mining code of the Netherlands consisted purely and simply of the French law of April 21st, 1810, subsequently modified in some respects as to its form. It is true that the law was interpreted by the Dutch Government in a fashion that did not accord with French or Belgian notions of jurisprudence, those who applied for mining concessions being compelled to agree to certain additional clauses (in the matters of expiry of lease, preliminary security, etc.) which would be regarded as illegal in France or Belgium.

Consequent on the discovery in Dutch Limburg of that coal-basin, which has since been found to extend westward into Belgian Limburg, the Campine, and the province of Antwerp, the Dutch Government felt impelled to supplement and modify previous legislation by the enactment of the laws of June

21st, 1901, July 24th, 1903, and April 27th, 1904. A French translation of the full text of these laws is given by the author in an appendix.

There appeared to be little doubt that the discovery of the new coal-basin was destined to bring about great changes in the industrial position of the Netherlands, but the key-note of the situation was the fixed determination of the Government to reserve for the State at least a certain portion of the coal-field. As the result of the bore-holes, there was in 1898 a race for mining concessions on the part of sundry capitalists. Finding that the task of allotting these equitably would probably prove all but impossible, the Dutch Government instituted in 1899 a special Commission to investigate the whole question. The results of the enquiry may be summed up as follows:—The area over which workable coal-seams extend in Dutch Limburg amounts to 35,830 acres, of which part should be reserved for working by the State. This reserved portion would cover about 11,120 acres, and probably contains about 820 million tons of coal. The remainder should be allotted in concessions of not less than 1,235 and not more than 2,471 acres, in order to encourage legitimate competition. It was noted, by the way, that most of the existing concessions were in the hands of foreign capitalists or foreign syndicates, and that the demands for fresh concessions totalled up to an area which was more than three times that of the proved coal-field. Weighty reasons were assigned for the State-working of a portion of the coal-field, one being that the State-mines would serve as a model or a standard for the private collieries to work up to; also, that consumers would thereby be protected from the abuses that arise from the formation of rings or trusts. As a people, the Dutch have no great bent towards mining enterprise nor much experience in it; and, if the State did not intervene, the Commission foresaw that all the new mines would fall into the hands of foreigners. The Government, in 1901, presented a bill based on these conclusions to Parliament, but the drastic resolution was passed to reserve the entire area of 35,830 acres for working by the State; then by the law of 1903, the Government reserved to itself the right of searching for coal north and east of the known coal-field for six years thereafter, leaving very little ground open to the enterprise of private prospectors. By the law of 1904, the abrogation of concessions, when granted, is declared, if mining operations have not been started therein within a given period, or have been suspended; also if the concessionaire has failed to comply with the various regulations and clauses by which he is bound. The working of the State property has now begun, shafts being sunk by the freezing system. L. L. B.

UNDERGROUND TEMPERATURES IN THE PAS-DE-CALAIS, FRANCE.

Mesures géothermiques effectuées dans le Bassin du Pas-de-Calais. By FÉLIX LEPRINCE-RINGUET. *Comptes-rendus hebdomadaires des Séances de l'Académie des Sciences*, 1907, *vol. cxliv., pages* 347-349.

Within recent years a great number of bore-holes have been put down in the southern portion of the Pas-de-Calais, some of which have struck the Coal-measures at depths ranging from 2,300 to 4,600 feet. These measures are not only overlain hereabouts by Chalk, but are in places (together with the underlying Carboniferous Limestone and Upper Devonian) actually thrust under the older rocks, that is, the Lower Devonian and the Silurian. It was deemed a matter of interest to ascertain to what extent increase of temperature was likely to prove a factor in determining the conditions of working such deep-lying deposits; and accordingly geothermic measurements were made, ultimately by means of maximum thermometers with a range of only 16 degrees,

extremely hard, light, and short, suspended by very elastic brass wires within a long steel shell which was screwed to the lower extremity of the boring-rods. The results proved that the average value of the geothermic degree in the Silurian and Devonian strata, consisting of a succession of clay-slates and quartzitic grits many times repeated, is expressed in terms of depth by 185½ feet; this implies that the conductivity of these rocks is very great indeed. The results obtained by the author in the Cretaceous rocks and in the Coal-measures are too divergent to permit of an average being struck; but, at Drocourt, near Fresnoy, the geothermic degree of the Coal-measures is expressed in terms of vertical depth by 132¼ feet. Calling the geothermic degree u, the conductivity of a given rock k, and the vertical flow of heat per unity of surface q, the author shows that $u=q/k$. The practical result of the measurements recorded by him is, that at a depth of about 4,000 feet, the new pits to be sunk in the south of the Pas-de-Calais will have to deal with temperatures varying between 95° and 105° Fahr. At the same depth in Lorraine, the temperatures already met with in the new bore-holes for coal range from 120° to 130° Fahr.

L. L. B.

SEASONAL DISTRIBUTION OF EARTH-TREMORS.

(1) *Sur les Lois de Répartition mensuelle des Tremblements de Terre.* *By* F. DE MONTESSUS DE BALLORE. *Bulletin de la Société belge de Géologie, de Paléontologie et d'Hydrologie*, 1906, *vol. xx., Procès-verbaux, pages* 183-191.

The author points out that it is a merely fortuitous coincidence that, in temperate regions, seismic phenomena appear all the year round to follow the variations of the barometer. Barometric pressure can hardly be invoked as a factor, with any sense of proportion, in the case of those earthquakes which are of deep-seated origin. These macroseismic phenomena must be regarded as entirely distinct from microseismic movements, which are mere minor vibrations of the most superficial portion of the earth's crust, due to an infinite variety of causes—some of these causes being hardly determined or understood as yet.

(2) *Sur les prétendues Lois de Répartition mensuelle des Tremblements de Terre.* *By* F. DE MONTESSUS DE BALLORE. *Comptes-rendus hebdomadaires des Séances de l'Académie des Sciences*, 1906, *vol. cxliii., pages* 146-147.

Collating the records of about 60,000 earthquakes from 81 different catalogues, which the author has recently examined, he arrives at the result that the maximum of apparent seismic frequency occurring in October to March in latitudes higher than 45 degrees is 90 per cent., and from April to September 10 per cent.; and from October to March in latitudes lower than 45 degrees, 47 per cent., and from April to September, 49 per cent. (4 per cent. being neither maximum nor minimum). Therefore, northern regions (lying in latitudes higher than 45 degrees) show an enormous predominance of the maximum apparent seismic frequency during the cold season, while the southern regions (lying in latitudes lower than 45 degrees) are comparatively neutral in this regard.

Remembering that the number of slight earth-tremors is incomparably greater than that of strong or violent shocks, and that the average man if within doors and resting perceives the slighter tremors far more easily than when he is out of doors and engaged in active work, these results are immediately explicable. In the northern regions, it is in the cold season, from October to March, that people spend most of their time indoors, and that there is least outdoor work done; whereas in the southern regions the conditions of life are

much the same all the year round. The personal factor furnishes thus a key to this supposed seismic maximum in winter; and the conclusion remains that earthquakes are equally likely to occur at any season of the year.

L. L. B.

EARTH-TREMORS IN GREECE DURING THE YEARS 1900 TO 1903.

Étude des Séismes survenus en Grèce pendant les Années 1900-1903. *By* D. Eginitis. *Annales de l'Observatoire National d'Athènes*, 1906, *vol. iv., pages* 135-145.

Some account is given of the progress recently made in the organization of the Hellenic geodynamic department, started by the author at the Athens Observatory in 1892. Several hundred workers, stationed in various localities all over the kingdom, are entrusted with the systematic observation of earth-tremors; and at five localities (Athens, Calamate, Chalcis, Zante and Egion) the observing-stations are now equipped with Agamennone seismographs.

From January, 1900, to December, 1903, inclusive, no less than 1,284 seismic shocks were recorded in Greece, the greatest number in any one year (414) being observed in 1902. The annual average for the quadrennium (321), is very much less than the annual average (531) observed in the years 1893 to 1898; while in the year 1899 no less than 567 seismic shocks were recorded. The only shock that had destructive effects during the period under review, was the sufficiently violent earthquake which centred in the island of Cythere. All the other shocks were comparatively feeble, especially in relation to their frequency. The general monthly average was 27, as compared with a monthly average of 44 shocks in the years 1893 to 1898; in both periods, however, it is noteworthy that shocks were more frequent in the cold than in the hot season. Seismicity appears to increase from November to February, and thenceforward diminishes almost continuously until October, the months of greatest earthquake frequency being January, February, March and April. With regard to diurnal frequency, shocks appear to be more numerous by night than by day, the maximum occurring between 10 p.m. and 4 a.m., and more especially between 2 a.m. and 4 a.m. And this contrast cannot be put down to the fact that, in the quiet of the nocturnal hours, shocks are more easily perceptible; for, eliminating the human factor, and taking simply the automatic seismographic records, the author still finds that the number of shocks is greater by night than by day. As to the possible influence of the phases of the moon on earthquake-frequency, the tables show a maximum of seismicity about the period of full moon, and a minimum in the first quarter; and similarly a maximum at the perigee of the lunar orbit, and a minimum at the apogee (except in 1901). Earth-tremors are far more frequent (about double in number) at aphelion than at perihelion of the terrestrial orbit.

Lists are given of the geographical distribution of the observed tremors within Greek territory (this includes, of course, certain of the islands as well as the mainland), and the paper concludes with a table of the velocity of propagation observed in the case of thirteen earthquakes, commencing with that of Bucharest on March 31st, 1901, and terminating with that of Cythere on August 11th, 1903. The table shows that, generally speaking, the velocity of propagation of the seismic waves diminishes as the distance of the affected locality from the epicentre increases. But this rule is not of universal application, for the nature and sequence of the rocks affected by an earthquake must have considerable, or at least noticeable influence on its velocity of propagation.

L. L. B.

EARTHQUAKE OF 1905 IN CALABRIA, ITALY.

(1) *Il grande Terremoto calabro dell' 8 Settembre 1905.* *By* MARIO BARATTA. *Atti della Società toscana di Scienze naturali*, 1906, *Memorie, vol. xxii., pages* 57-80, *with* 2 *figures in the text.*

A slight fore-shock was felt by some persons at about 11 p.m. on September 7th; but the principal shock started about 2·45 a.m. on the 8th, with a thrice-repeated violent saltatory motion, succeeded after an interval of a couple of seconds by undulatory movements of variable direction, giving the impression of torsional motion, and lasting for at least 35 seconds. A loud rumbling noise, comparable to the thunderous roar of a heavy railway-train entering a tunnel, began a little before the shock, and lasted throughout it with increasing intensity. The town of Monteleone suffered serious damage, a great number of buildings being wholly or in part reduced to ruins, or at least rendered uninhabitable. A very few houses escaped, owing to their exceptionally solid construction and to the direction in which they were oriented. This town furnishes another example of the fact that buildings founded on solid rock are, by comparison with those the foundations of which rest upon a rubbly or loose subsoil, comparatively immune to seismic phenomena.

A description is given of the destructive effects of the earthquake in the outlying villages, and the author observes that, poor as the general type of building is in Monteleone itself, the methods and materials in use in these villages are still more open to criticism. At Stefanaconi, 65 persons were killed on the spot, and 30 were seriously injured; Piscopio, a village numbering 1,162 inhabitants, was utterly destroyed, 59 persons being killed and 250 injured; 84 were killed in the parish of San Gregorio d'Ippona, where the bell-tower of the church crashed to the ground. At Cessaneti, the same phases of saltatory and undulatory motion were observed as at Monteleone; 7 persons were killed, and half a score injured. The havoc wrought was much greater in all those cases where buildings were founded on loose or rubbly subsoil. This factor is of equal importance, in appraising the result of earthquakes, with the architectural factor (mode of building and materials used).

The earthquake of September 8th is termed by the author "polycentric," because within the area of greatest intensity there was a principal epicentrum in the Monteleone district; another one in the neighbourhood of Ajello-Martirano; and, in all probability, a third in the belt defined by Montalto-Uffugo-Rende.

(2) *Sur le Tremblement de Terre calabrais du 8 Septembre 1905.* *By* G. MERCALLI. *Comptes-rendus hebdomadaires des Séances de l'Académie des Sciences*, 1907, *vol. cxliv., pages* 110-112.

This author points out that the following phenomena were monitory forerunners of the great earthquake: (1) two minor shocks which took place between September 3rd and 8th, in the Basilicata region; (2) a preliminary recrudescence of activity in the Stromboli volcano, and a very apparent earth-tremor throughout Western Calabria on the morning of August 29th; (3) a great increase of hydrogen sulphide in the thermal waters of Sambiase (Nicastro); and (4) a slight earth-tremor, which was felt about 1 hour before the principal shock, throughout the area subsequently devastated by that shock. The great Calabrian earthquake was unaccompanied by any permanent dislocation of the subsoil, and so the author classifies it among the seisms which are usually termed "perimetric," but to which he assigns the appellation "inter-volcanic." The devastated area included no less than 44 villages or hamlets; it measured 62 miles in length from Bisignano to Mileto, and 25 miles in its

greatest breadth between Olivadi and Briatico. That the epicentrum was deepseated is shown by the fact that the earthquake was recorded by the instruments in all the seismological observatories of Europe, and as far afield as Japan and the Philippines, Toronto and Cape Town. The complication and the variability in direction of the movements—saltatory, undulatory and giratory, already mentioned in Dr. Baratta's memoir—are attributed by Dr. Mercalli to the resurge of the seismic waves from against the mass of crystalline rocks which ranges throughout the devastated area, and also to displacement of the epicentrum in the course of the earthquake. The very irregular distribution of the damage to buildings, etc., was due to a variety of causes. Given equal intensity, the seismic movements wrought greatest havoc in villages built on slopes or on isolated, not very extensive, eminences; also in those built on the Pliocene yellow sands, on the loose Miocene molasse, on patches of Quaternary alluvium and on talus-slopes, or on the rubble formed by the subsoil decomposition of the crystalline rocks. Moreover, the effect of the shock was most disastrous at the contact of these rocks and the overlying Tertiary or Quaternary deposits, on account of the sudden stratigraphical unconformity coinciding with a great difference of elasticity in the mass through which the earthquake was travelling. The great loss of life is largely attributable to the wretched structural conditions of the habitations, which were mostly old and but scantily repaired after having been damaged in previous earthquakes. Dr. Mercalli, after very careful investigation, arrived at the conclusion that there were really two epicentra: one in the Monteleone district, and the other in the south-western portion of the upper valley of the Crati. Numerous after-shocks, no less than 100 in the first three months, followed hard upon the principal earthquake. He assigns reasons for rejecting any causal connexion between the coincident renewed volcanic activity of Stromboli and of Vesuvius and that earthquake; probably both the volcanic and the seismic manifestations were due to certain endogenic influences, to which all the geodynamic phenomena of the region may be ultimately traced.

Although the sea was calm, and there was no wind after the principal shock, the waters rose and fell, with a periodicity of $7\frac{1}{2}$ minutes, along the entire Tyrrhenian coast of Central Calabria, the difference from the normal level attaining at some points a maximum of $4\frac{1}{4}$ feet. L. L. B.

EARTHQUAKE IN FINLAND, 1902.

Jordskalfvet den 10. April, 1902. By J. E. Rosberg. *Fennia (Bulletin de la Société de Géographie de Finlande)*, 1903-1904, *vol. xxi., No.* 2, *pages* 1-28 *and* 1 *plate (map).*

Earthquakes are of tolerably frequent occurrence in Finland, but their effects are seldom disastrous. Most of the shocks hitherto recorded, including the earthquakes of 1882 and 1898, proceeded from epicentra situated in the northern portion of the gulf of Bothnia, along a line approximately coincident with that which might be drawn between the towns of Torneå and Uleåborg, and the epicentral areas were almost invariably oriented north-west and south-east.

Concerning the earthquake of April 10th, 1902, the available information is derived from about a hundred separate reports. The shock was felt within a minute or two of 9·15 p.m., and lasted only a few seconds. The epicentral area is defined by a line drawn from north-west to south-east through Uleåborg and Nurmes, around which a great ellipse may be described, the principal axis lying approximately between Torneå and Joensuu. What the writer terms

"tremor-apophyses" can be traced stretching into Southern Finland and Russian Karelia. It is noteworthy that all the records come from localities situated on a comparatively loose soil (that is, where the immediate substratum is not solid rock).

In the epicentral area and its immediate neighbourhood, the phenomenon is described as resembling the roar of an oncoming wind, followed by a very perceptible undulation of the ground, or in places one or two saltatory motions, and then a general vibration of the soil. Without the immediate neighbourhood of the epicentral area, the separate motions were merged into one. The direction of propagation is a matter on which extremely various reports have been obtained: on the whole, it is described either as being from north-west to south-east, or as precisely the reverse. During the earthquake a sound was heard comparable to the clattering of rapidly driven carts, and an ominous cracking in the roofs. Windows rattled, suspended objects swung to and fro, small fissures appeared in the walls of buildings, and many persons were aroused from sleep. Church-towers were especially shaken, and in some localities a screw-like twisting motion was observed. The weather was calm and very cold, and the barometer much above the normal height. No magnetic disturbances were recorded.

There appears to be little doubt that this is a case of an earthquake originated by faults. The main tectonic lines of the region have the same strike as the principal axis of the epicentral area. Possibly the enormous transport of sediment (? removed by erosion) still taking place from this district is contributing to changes in crust-pressure. Moreover, so far as can be ascertained, secular elevation of the land is more marked to the south-west of the epicentral area than within it. L. L. B.

CHILIAN EARTHQUAKE OF AUGUST, 1906.

Einige Ergebnisse der Untersuchungen über das mittelchilenische Erdbeben vom 16. August 1906. By Hans Steffen. *Petermanns Mitteilungen*, 1907, *vol. liii., pages* 132-138 *and a map.*

In the macroseismic area embraced by the so-called Valparaiso earthquake of August 16th, 1906, covering practically a fifth of the South American continent, only one reliable seismographic record is forthcoming—that, namely, furnished by the Milne horizontal pendulum at Pilar, in the Argentine province of Córdoba. In the region west of the Cordilleras where the most violent shocks occurred, some, what may almost be termed fortuitous, records were obtained from a few primitive instruments set up by amateurs; these yielded detailed results only in regard to the direction and intensity of the shock. The author has, however, been able, by various methods, to bring together sufficient material for forming a considered opinion as to the general character of the phenomena.

The shocks perceptible to the ordinary human senses were observed over the greater part of the South American continent south of latitude 18 degrees south, from Tacna at the northern extremity of this triangular area to the island of Chiloé at the southern extremity. On the east, the line of the Rio Paraná-Rio de la Plata may be regarded as defining the boundary of the macroseismic belt, although on the north-east that boundary is uncertain. On the west, the Juan-Fernandez archipelago, lying over 400 miles distant from the coast at Valparaiso, is the probable boundary. However that may be, the north-to-south extension of the earthquake (1,740 miles) had only been exceeded in the Chile-Peru coastal belt on one previous occasion—the disastrous shock of May 9th, 1877; while no sufficiently reliable data of the east-

to-west extension of former earthquakes are available for comparison in that direction.

The first perceptible shock on August 16th, 1906, took place about 7·56 p.m., and in the central portion of the macroseismic area it lasted as long as 4 or 5 minutes, being succeeded after an interval of comparative tranquillity by a more violent shock of barely one minute's duration. The relatively quiet interval at Santiago cannot have lasted less than 4 minutes. At Pilar, 435 miles away on the other side of the Andes, the seismographic record chronicles a fore-shock of 9·7 minutes' duration, followed by a principal shock of 12 minutes' duration, then by a succession of alternately feebler and more violent shocks lasting for about an hour, after which the gradual decrease of the vibrations was perceptible for a further 77 minutes, the total duration of the phenomena being thus somewhat over 2½ hours. In the remoter portions of the macroseismic area the differentiation of the two phases was not perceptible, the phenomena being described as a remarkably long succession of undulatory vibrations of uniform intensity. From 30 degrees to near 38 degrees south latitude, and from the base of the great Cordilleras to the Pacific sea-board, very marked vertical movements (in the form of fairly-violent saltatory vibrations) were undoubtedly observed. It would almost seem as if the entire macroseismic area above defined had been suddenly imbued with a tendency to centrifugal motion.

The horizontal vibrations appear to have been propagated in all directions, no single direction being really predominant, and in the epicentral area there seems to have been actually torsional movement,

With regard to the intensity of the earthquake, the Commission of Enquiry appointed by the Chilian Government preferred to make use of the Mercalli scale (despite its acknowledged defects) instead of the Rossi-Forel scale. The map constructed on that basis shows that the pleistoseismic area (seventh to tenth in the scale) embraces the central portion of Chile, between 31½ degrees and 38 degrees south latitude, from the western base of the Cordilleras to the shores of the Pacific, the isoseismals defining a series of elongated semi-ellipses. The major axes of these, for at all events a distance of 310 miles, coincide approximately with the coast-line; but at the northern extremity they trend more inland, their general strike being north 18 degrees east. The concentricity of the isoseismal curves is not perfect, and so the pleistoseismic area bounded by the ninth isoseismal appears to be shifted somewhat towards the northern boundary of the region affected by the earthquake. Within it the low-lying coastlands of Matanzas, San Antonio, Tunquen, Valparaiso, Viña del Mar and Zupallar, as also the valley-depressions of Melipilla, Casablanca, Limache and Nogales, some 19 to 22 miles inland, define the localities of the tenth and greatest seismic intensity.

The rocks of which the pleistoseismic area is built up are predominantly the ancient crystallines of the coastal Cordilleras, but in the extreme north and north-east (between Limache and Llai-Llai and south of La Ligua) the Mesozoic shales and conglomerates come in. Although no relationship between the seismic phenomena and the stratification or geological chronology of the rocks can be postulated, the well-known dependence of the aforesaid phenomena on the character of the surface-soil and subsoil may be traced positively step by step. Even the varying humidity of the soil appears to account for variations in the earthquake-phenomena within neighbouring portions of one and the same valley, and so too in certain coastal depressions where fissures and miniature sand-craters have been formed on the borders of lagoons, etc.

The circumstance that, shortly before the commencement of the earthquake, heavy showers of rain were experienced over the whole of Central Chile, appears to have ominously intensified the seismic phenomena in many localities. Thus the little town of Limache was razed to the ground, and out of its 3,500 inhabitants no less than 116 perished on the spot; the surface-soil there, a loose sand some 4 feet thick, overlies an impermeable clay (over 2½ feet thick), and so is water-logged after heavy rains. So, too, in the sand-dune region, which occupies a great extent of the Chilian coast, the effects of the earthquake were conspicuously manifest—thus San Antonio, a settlement north of the mouth of the Rio Maipu, was buried by the shifting and collapse of a dune.

The intensity of the earthquake seems to have diminished far more rapidly northward than southward, in the coastal region at all events. On the whole, however, the isoseismals coincide more or less closely with the tectonic lines defined by the Pacific sea-board, the Central Chilian longitudinal plain, and the Cordilleras of the Andes. In the southern latitudes, as far as the entrance of Arauco Bay (37 degrees south latitude), no exceptional motion of the sea was observed in association with the earthquake-phenomena; but at Coronel, on the northern shore of that bay, there was a tremendous swell, although the ocean remained unrippled by the slightest breath of wind. At Penco, which had on previous occasions suffered from these so-called tidal waves, the threefold and fourfold repetition of such waves accompanying the earthquake here described sent the panic-stricken inhabitants on the trot for the neighbouring hills. Other seaside localities report similarly alarming waves; but, singularly enough, still farther north, along the coasts of the provinces of Colchagua, Santiago, Valparaiso and Aconcagua, which suffered most severely from the earthquake, there was nothing abnormal in the behaviour of the Pacific. The source of the tectonic disturbance which gave rise to the earthquake must not be sought in the depths of that ocean.

There is not sufficient evidence at hand to determine whether the tidal wave observed on the shores of the Hawaii islands was in reality associated with the Chilian earthquake; but, on the whole, the balance of the recorded facts tells against such an hypothesis.

Perhaps one of the most interesting features of the earthquake of August 16th, 1906, is the slight elevation of the coast-line in certain districts with the exception of those lying north of 31½ degrees south latitude and south of 35 degrees south latitude. This elevation coincides, where it is most marked, with the areas of highest seismic intensity, and appears to have attained its maximum (which never exceeded 2·65 feet) in the north. In the Valparaiso area, after-shocks were still being felt almost daily in March, 1907, that is, seven months subsequently to the principal shock. L. L. B.

EARTHQUAKES OF 1906 AT MASAYA, NICARAGUA.

Erdbebenserie von Masaya (Nicaragua), 1. bis 5. Januar 1906. By KARL SAPPER. *Centralblatt für Mineralogie, Geologie und Paläontologie*, 1906, *pages* 257-259, *with a map in the text.*

At 10·30 p.m. on December 31st, 1905, a premonitory fore-shock was felt, followed at about 5·30 a.m. on New Year's day by a shock sufficiently violent to cause general excitement in the district. Meanwhile rumblings were heard at every few minutes' interval, supposedly from the volcano of Santiago, 10 miles or so to the west of the town of Masaya. Light earth-tremors accompanied the rumbling. About 5 p.m., the inhabitants were alarmed by a still

more violent shock, and at 6 a.m. on January 2nd, another earthquake took place, causing damage to several buildings, many persons being injured by falling masonry. A series of fifteen lighter shocks followed in the course of the morning, and four more violent shocks took place between noon and 7·30 p.m. The night was in comparison tranquil, but light tremors occurred with almost mathematical precision every 2 minutes. Three violent shocks took place on the morning of January 3rd, while the subterranean rumblings and slight tremors were practically continuous. The seismic phenomena recurred in a violent form on January 5th (the shocks on January 4th being comparatively unimportant), and in the latter half of the day altogether 38 shocks of more or less intensity took place. At 10 p.m., loud rumbling was heard, followed by a final violent shock. Complete tranquillity then ensued; and on January 10th the police-authorities felt justified in requesting the inhabitants of Masaya, who had fled *en masse* to Granada, Tisma, Catarina, and other towns, to return to their homes.

The shocks were not propagated over any considerable distance, nor can the intensity have been very great, since no building was laid completely in ruins. The road from Masaya to the lake of the same name is bordered by crags of tuff, and so much débris crashed down from these that the road was completely blocked.

The Santiago volcano, which had been active since the summer of 1902, gave vent to no smoke or steam-cloud during the entire period of the earthquakes. It was not until January 9th that a smoke-pillar was observed rising from it again. It was reported, however, that at the time of the violent shock which took place at 1·30 p.m. on January 2nd, the parasitic cone of Pelon had opened up, and that smoke and gases had issued from a fissure therein. A Commission of Enquiry has since stated that a new crater had begun to form between the Santiago volcano and El Pelon, and that gases and steam were shooting forth from fissures exceeding 16 inches in width.

L. L. B.

CYPERACEÆ AND THE ACCUMULATION OF ALLUVIAL GOLD.

Le Cyperus tuberosus dans les Terrains aurifères de Madagascar. *By* H. JUMELLE *and* H. PERRIER DE LA BATHIE. *Comptes-rendus hebdomadaires des Séances de l'Académie des Sciences*, 1907, *vol. cxlv.*, *pages* 485-487.

In all the streams that course through the older rocks of Madagascar various kinds of sedges grow into such a thick and tenacious mass with interlacing rootlets and rhizomes, that the most formidable freshets or spates of the rainy season fail to dislodge them. These sedges are assignable to several species, the commonest of which is *Cyperus tuberosus* formâ *tenuiflorus*: it grows to a height of 12 or 15 inches, and its triangular stem is slightly swollen at the base. Attention may also be drawn to its unusually narrow leaves. In the rainy season this carpet of sedges in, for example, the basin of the Bemarivo, a tributary of the Sofia, is covered by the rush of waters carrying down black sands and native gold in suspension. Some of this float-gold (which, together with a few silicified trunks of conifers, is perhaps all that remains of Permian strata long ago swept off by denudation) is trapped by the interlacing rootlets and rhizomes, and can be extracted therefrom in the dry season, when the waters are low. By washing the rootlets, an average of 1½ grains of gold per cubic yard is obtained; on subsequently burning these same rootlets, about 3 grains of gold are obtained per ton of ash.

Another point worthy of remark is that these sedges play, if but indirectly, a part in the formation of gold-bearing ferruginous conglomerates. Premising

that such conglomerates are the outcome of the deposition, by the agency of various micro-organisms, of the oxides of iron which partly make up the black sands, and that these micro-organisms are powerless to bring about such a deposition in running water, it will be observed that the requisite life-conditions and environment are found in the mud or slime which is retained during the dry season among the rootlets and rhizomes of the above-described *Cyperus*. This will, perhaps, explain also how ferruginous concretions often occur on the slopes of steeply inclined rocks, an impossible situation if mere deposition of iron in the ordinary way (without the intervention of bacterial agencies) is postulated. A further suggestion is made as to the possibility that certain species of bacteria may be capable of acting on gold and causing it to enter into combination with other substances; and one might then understand how it is that occasionally gold is found in the conglomerates in the non-free state.

L. L. B.

HUMUS AND THE FORMATION OF BOG- AND LAKE-ORES.

Die Bedeutung der wasserlöslichen Humusstoffe (Humussole) für die Bildung der See- und Sumpferze. By Ossian Aschan. *Zeitschrift für praktische Geologie*, 1907, *vol. xv., pages* 56-62.

In Finland, the "country of the thousand lakes," the fresh water (with the exception of spring-water) is everywhere coloured by the humic substances held in solution therein, and it has been calculated that the Finnish rivers carry every year down to the Baltic 1,400,000 tons of such substances. In the same time they carry down about 1,750,000 tons of inorganic substances.

Careful analyses of the humic material derived from different river- and lake-waters in Finland show considerable variations in the percentage of carbon, hydrogen, nitrogen and oxygen, which are its principal constituents; but, considering how various in composition and origin are the substances from which the humic material is generated, there is nothing to give cause for surprise in this. Leaving nitrogen out of account, it may be of interest to note that the mean percentages indicate an approximation to the carbohydrates of the cellulose or amylaceous group. Bearing this in mind, and noting further the presence of nitrogenous and phosphorus-compounds, as also (all but invariably) sulphur in organic combination, the idea suggests itself that, under suitable conditions, the "humus sole" (as the author denotes the presumably colloidal solutions of humic material) may well serve as nutriment for certain lower organisms. It is surprising how little alteration this material undergoes, in the course of its journey of 250 miles or so from the Finnish lakes down to the Baltic; but once in the sea, it oxidizes with comparative rapidity—perhaps through the agency of certain forms of plankton. In fresh water, the determining factor in the assimilation of humic products by organisms is probably the simultaneous presence of certain metallic salts—chiefly those of calcium, magnesium and iron. In combination with the humic acids they form then humates. Now, the fresh waters of Finland, flowing over a predominantly granitic soil, are very poor in salts of lime and magnesia, wherein the sea-waters are rich; but there remain the possible humates of iron, and these in all probability play an important part in the formation of the lake- and bog-ores that are of such frequent occurrence in Finland.

It is a commonplace among geologists that the humic acids in the soil have much to do with the decomposition and leaching-out of rock-constituents. But these acids, of themselves insoluble, cannot fulfil their function unless they are, provisionally at least, taken up by water: in a word, the real decomposing agents are the "humus sols." The author agrees in the view that car-

bonic acid and ammonia, the terminal products of the simultaneous oxidation of the humic acids, also play a part in the chemical processes involved in the decomposition of the rock-constituents; but he adds, on his own behalf, the opinion that biological processes, initiated by certain lower organisms, form a necessary factor in this humic decomposition. He admits that the attempt to refer the formation of ordinary lake- and bog-iron-ores to the presence of soluble humic compounds has hardly gone as yet beyond the hypothetical stage; notwithstanding which he holds that there are many facts to be adduced in favour of the hypothesis, among them being the following:—When ferric and ferrous compounds in solution come into contact with "humus sols," a recombination takes place wherein chemical, and possibly physical forces as well, come into play. According to the conditions of concentration and to the presence of definite varieties of ions, after the ferrous compounds have been converted into ferric compounds by the agency of oxygen dissolved in water with the occasional co-operation of micro-organisms, precipitation of ferric humates takes place, or else they remain in solution. When completely dried at temperatures ranging from 212° to 230° Fahr., the soluble humic substances contain carbon, hydrogen, and oxygen in proportions that differ but slightly from those of the multimolecular carbohydrates, in addition to an average of 2 per cent. of nitrogen, some phosphorus, and sulphur in comparatively minute quantity. Consequently, as was above suggested, in the presence of basic substances this humic material would furnish an appropriate nutriment for lower organisms. In all probability, the ferrous and ferric humates, whether as precipitates or in solution, are the food of certain micro-organisms, and are by them decomposed into less complex compounds with the simultaneous liberation of iron in the form of a hydrated oxide. The organic carbon present in all the Finnish lake- and bog-iron-ores that have been examined occurs in the shape of remnants of humic substances, and so there appears to be no room for doubt that such substances play a considerable part in the formation of these ores. Further analyses of 21 samples of lake-ore and 11 of bog-ore, showed that they all contained humic acids, in proportions ranging roughly between 2 and 8 per cent. The very structure of the iron-ores (pisolites, oolites, etc.) points to the activity of micro-organisms in their formation.

Attention is directed, by the way, to the very common, and in some localities very abundant, occurrence of carbon in some form or other (graphite, anthracite, bitumen, etc.) in the neighbourhood of many of the bedded iron-ores of Scandinavia; also to the blackband ironstones which occur among the Coal-measures of Scotland and Westphalia, as showing that soluble humic material and micro-organisms must have played their part in the formation of iron-ores in the remote Carboniferous age, just as in our own day.

L. L. B.

MANGANIFEROUS BOG-ORE AND THE FORMATION OF MANGANESE-DEPOSITS.

Über Manganwiesenerz und über das Verhältnis zwischen Eisen und Mangan in den See- und Wiesenerzen. *By* J. H. L. Vogt. *Zeitschrift für praktische Geologie*, 1906, *vol. xiv., pages* 217-233, *with 5 figures in the text.*

The first portion of this memoir is devoted to a description of certain occurrences of manganiferous bog-ore in Norway, which the author has had the opportunity of investigating within recent years. At Glitrevand in Lier, 25 miles due west of Christiania and barely 9 miles north-north-west of Drammen, the deposits of bog-ore are found in a series of marshy valleys which are cut in a great mass of highly-fissured intrusive quartz-porphyry (covering an area

of some 6 square miles), and in the neighbouring, intimately associated, Drammen granitite. Taking the Borvikdal as an example, a valley which has a maximum breadth of 300 feet, the ore-deposit in the valley-bottom overlies the ground-moraine (a sandy boulder-clay) and is in its turn overlain by peat to a thickness of 8 to 20 inches. The ore-body itself averages $2\frac{1}{2}$ to $3\frac{1}{4}$ feet in thickness, but sometimes thins down to 4 inches, and occasionally thickens out to 10 feet. It is evidently of post-Glacial age, and the plant-remains which are found in it show that it was forming after the migration of the pines (*Pinus sylvestris*) into the district. Whether deposition is still going on to a small extent is uncertain. The ore is extremely cavernous, and contains much hygroscopic water when freshly extracted. On drying, it for the most part crumbles away to powder. That portion of the ore-body which lies close to the solid rock (quartz-porphyry) that walls in the valley shows a curious interbanding of blackish-brown manganese-ochre and brownish-yellow iron-ochre: the former ore being practically free from clayey particles, and the latter frequently full of them. Within a foot of the porphyry-wall there is perhaps more iron-ochre than manganese-ochre, the proportions becoming gradually interverted as one recedes from that wall, until some 60 feet away iron-ochre is scarcely present in any proportion worth mentioning. Analyses are given of the dried ore, the most interesting, perhaps, being that of an average commercial sample containing 41·2 per cent. of metallic manganese. Attempts have been made to work the Borvikdal deposit on an industrial scale, but so far only what may be called "samples" have been dug out, to the extent of 100 tons. The author estimates roughly the amount of manganiferous ochre in sight as equivalent to 10,000 tons of dried ore. Nearly all the fissures in the quartz-porphyry itself are filmed over with dendritic manganese, and in the neighbouring Drammen granitite at Myrsäteren the films become positively veins, to such a degree that a few years ago an attempt was made to work them opencast. Brief descriptions are given of the manganese ore-deposits of Flatdal in Telemarken; Idsö in the parish of Strand, district of Stavanger; and the southern part of Tysvär.

Expressly excluding from consideration the manganiferous nodules which are known to be forming at the present day in the abysmal depths of the ocean, the author proceeds to consider the relationship between iron and manganese in lacustrine and bog-ores. He quotes in this connexion several analyses, showing the gradations from an ore containing much iron and little manganese to one containing a great deal of manganese and scarcely any iron. In regard to Finnish ores, the rule seems universal that the lake-ores richest in manganese occur in soft ground where rushy growth flourishes, whereas the ores richest in iron are found on a hard or sandy bottom where reeds grow. Then, as to the relationship between iron, manganese, and the other heavy metals in the crust of the earth and in lake-and-bog ores respectively. In the earth's crust, the proportion of manganese to iron may be stated roughly as 1:50 or 60; and, although the difference seems enormous, it will be found that manganese is actually next to iron in order of abundance. In lake- and bog-ores the proportion is less startling: 1 of manganese corresponds to anything between 25 and 50 of iron; and this is only a very general average, Swedish and Finnish ores showing a much higher ratio of manganese. It may be observed that manganese possesses a higher solubility-tension than iron, on the whole, and is consequently taken up more easily than iron by the solutions which percolate through the rocks; the more so that manganese predominantly occurs in the silicates, from which it is released on weathering with somewhat greater facility than iron. Chromium, which comes next to manganese among the heavy metals in order of abundance, is extracted with difficulty by solution

from the rocks, and so it occurs in quite infinitesimal quantity in the manganiferous iron-ore deposits which are formed by hydrochemical processes.

Turning then to those sedimentary manganiferous deposits, the formation of which can be explained in the same way as the formation of manganese lake- and bog-ores, the author reckons among them the finest ore-deposits of the kind as yet known—namely, those of Kutais in the Caucasus and Nikopol on the Dnieper, the former being of Eocene and the latter of Oligocene age. It may be noted parenthetically that the Tertiary manganiferous deposits of Russia account for about one half of the entire manganese-output of the world. Genetically considered, all the known manganiferous occurrences can be classified into a series of groups; among these that which is of greatest industrial importance is the sedimentary group, more especially the division of lake- and bog-ores.

A section is devoted to the question of separate precipitation of compounds of iron and of manganese. This precipitation may be brought about by organic agencies, animal or vegetable; and also by what may be termed purely chemical processes. The latter, leaving metasomatic phenomena out of account, and considering only those that yield oxides and carbonates, result either (1) in neutral or reductive precipitation; or (2) in oxidic precipitation. Such ore-deposits as those of Glitrevand and the rich manganiferous lake-ores of Finland are the outcome of oxidic precipitation from solutions which were originally richer (by comparison) in iron and poorer in manganese than their precipitates.

In the next section, the reader's attention is called to the enrichment of metals, the distribution of which is otherwise comparatively limited, in manganiferous deposits. Postulating that, in the course of oxidic precipitation from solutions originally containing, besides iron and manganese, small quantities of nickel, cobalt, zinc, lead, copper, etc., the main mass of the iron is precipitated first of all, it follows that these rarer metals must concentrate together with the manganese in the residuum. And so it proves, in recent accumulations of lake- and bog-ores, that such metals do occur, even if that be in infinitesimal proportions; although the ratio is frequently much higher in manganese than in iron bog-ores. At Glitrevand, for instance, the latter contain 2 per cent. of zinc, and the ore of Golconda (Nevada) contains 2·78 per cent. of tungsten or wolfram oxide.

Concerning the frequent association of manganiferous deposits with granite, quartz-porphyry, and other highly siliceous rocks, the author observes that they have mostly been leached out of these, in part through weathering agencies. He admits that quite a number of manganiferous ore-deposits are associated with basic and intermediary eruptive rocks, but they are of far less importance than those connected with the acidic rocks. He does not profess to deal with the manganese-ores, mostly of metasomatic origin, which are associated with limestones and dolomites. L. L. B.

ORIGIN AND AGE OF METALLIFEROUS ORES.

Origine et Âge des Minerais Métallifères. *By* Alfred Ditte. *Revue Scientifique*, 1906, *series* 5, *vol. vi.*, *pages* 641-650.

Starting with the postulate that, in ultimate analysis, all the metals are originally derived from the heavy magma which forms the nucleus of the terrestrial spheroid, the author classifies as primary ore-deposits the inclusions in rocks, whence the secondary deposits (veins, lodes, decomposition-ores, and sedimentary ores) have originated. He regards mineralized waters as the essential agents in the formation of secondary ore-deposits as we now find them. By inclusions in rocks he implies those cases where the metallic particles are

actual constituents, just as much as any other mineral, of the igneous magma, and he places in the same category those primary ores which have undergone local concentration or segregation in the magma by a process of natural metallurgy.

The author lays considerable stress on Mr. A. Gautier's theory, that the water belched forth by volcanoes is really derived from the deep-lying crystalline rocks, which, by reason of the increasing irregularity of the pressures to which they are subjected and the instability of the continuously-contracting crust of the earth, are folded, dislocated, and broken up. Their broken masses, coming into contact with the incandescent lava, are thereby sufficiently heated to lose their combined water. It has been shown that a cubic foot of granite heated to redness will lose about 0·85 ton of water or steam; hence, it may be inferred that the deep-lying crystalline rocks themselves contain enough water to feed all the mineral springs of which we have any cognizance. The water thus liberated acts upon the deep-lying rocks, producing in turn an enormous amount of various gases at high pressure, of the same composition as those collected from the fumaroles. All this sufficiently accounts for the tremendous power as well as the irregularity of volcanic outbursts. The connexion between these physico-chemical and hydrothermal phenomena and the succession of chloridic, sulphidic and carbidic fumaroles is shown. The successive formation of stanniferous, auriferous, plumbiferous and zinciferous ores, etc., followed by the evolution of carbonic acid bringing possibly with it iron and lime, appears to correspond to successive stages of cooling or to increasing remoteness from the eruptive magma.

The question of the determination of the age of a given ore-deposit is discussed, and the author points out in this connexion the fundamental distinction between the metals which are associated with acid, abundantly fumarolic, rocks and those which are associated with basic rocks. In the first group, the succession appears to be fairly constant, from gold and tin, accompanied by bismuth and tungsten, etc., in the form of chloro-fluorides at temperatures exceeding 932° Fahr.; through sulphides (700° to 550° Fahr.) of antimony, lead, zinc (with copper, iron and cobalt), silver and mercury (below 400° Fahr.); to iron, manganese, etc., as carbonates and possibly chlorides (below 212° Fahr.). Reasons are assigned for the difficulty which is encountered in attempting to determine the age of metals of the second or basic-rock group.

The author then gives a brief chronological synopsis, as it may perhaps best be described, of the various gold, silver, tin, copper, zinc, lead and iron-ore deposits of the world. He concludes with the rather obvious remark that metalliferous ores are to be found through practically the entire thickness of the earth's crust, in the oldest as in the most recent formations, and ore-deposits are forming nowadays, both seen and unseen. L. L. B.

DIFFUSION-THEORY OF THE ORIGIN OF ORE-DEPOSITS.

Bemerkungen zur Diffusion fester Metalle in feste kristallinische Gesteine. By G. B. Trener. *Verhandlungen der kaiserlich-königlichen geologischen Reichsanstalt*, 1905, *pages* 366-370.

At the periphery of the granite-mass of Cima d'Asta a whole series of ore-deposits occurs, and, in endeavouring to account for their distribution in space, the most obviously applicable explanation is that of magmatic differentiation. But this explanation would not hold good unaided, for the ores do not only occur at the contact-zone of the granite; they have penetrated deep into the schists which mantle it over. For such circumstances the modern teachings in regard to ore-deposits have so far failed to find an adequate physical explana-

tion; and so the author has endeavoured to solve the problem by pursuing another line of research, that is, by carrying out experiments in regard to the diffusion of solid metals or their oxides into solid crystalline rocks. These, he holds, prove that such diffusion is quite as possible as that of some metals into other metals. He points out that, so soon as the ores have accumulated by, let us say, magmatic differentiation at the contact-zone of the eruptive mass, they find a cool wall in front of them: the molecules will consequently invade the pores of the schist-mantle, and will fill up such fissures or cavities as they meet on their way. He is convinced that the phenomena of diffusion play a considerable part in many geological processes, and more especially in the genesis of ore-deposits; but he is very far from claiming that they are a universal factor, or from wishing to dethrone in their favour the many processes arising from chemical reactions. He admits, indeed, that many necessary limitations hedge round the diffusion-theory: for instance, the diffusion-coefficient of the various metals and ores; the temperature; the magnitude of the osmotic pressure; the porosity and permeability of the rock in regard to metals; not to speak of the influence of other agencies, such as the chemical reactions already mentioned, and even the stratigraphical conditions and mineralogical composition of the rock itself. In this connexion one of the results of his experiments is of especial interest: mica-flakes appear to oppose an insurmountable obstacle to diffusion, and so this can hardly take place at all in schists which include thick continuous bands of mica bedded at right angles to the direction of diffusion. L. L. B.

FORMATION OF IRON-ORE DEPOSITS AND THEIR CLASSIFICATION.

Über die Entstehung und Einteilung der Eisenerzlagerstätten. *By* O. Stutzer. *Zeitschrift für das Berg-, Hütten- und Salinen-wesen im preussischen Staate*, 1906, *vol. liv., Abhandlungen, pages* 301-304.

Whenever a basalt is examined under the microscope, it is found to contain well-developed octahedra of magnetite, which in some cases form accumulations considerable enough to be of industrial importance: thus, at Taberg in Sweden accumulations of magnetite of this kind in a gabbro-massif form the object of mining operations, and similar titaniferous iron-ore deposits occur at Buschveldt in the Transvaal. To geologists such deposits are known as the result of magmatic differentiation; and they occur only in basic rocks, for otherwise, of course, the silicic acid set free from the molten magma would have combined with the iron to form silicates of iron.

In Northern Sweden, a somewhat different type of magmatic ore is found: the magnetite was evidently separated out at great depths, and then made its way upward. The famous ores of Gellivaara, Kiirunavaara, Luossavaara, etc., are shown by the latest researches to be magmatic veins or lodes of this kind. The deposits to which reference has so far been made are truly primary, in the sense that the iron has from the first crystallized out as magnetite. The only other category of primary magnetite-deposits are the so-called contact-deposits of the Banate in Hungary, the neighbourhood of Christiania, etc. These generally occur at the contact of limestone with deep-seated rocks, and their genesis is assigned to a diffusion of ferruginous gases or solutions from the plutonic rock into the limestone, etc.

The iron-ore lodes of the Erzgebirge, the Harz, the Siegerland, etc., represent the result of deposition in clefts and fissures from upward percolating ferruginous waters in the moribund or solfataric phase of vulcanicity. At Oberebersbach, near Kissingen, a recent iron-ochre deposit is actually being worked, formed by precipitation from thermal springs; and it is calculated that,

in the course of 10,000 years, the thermal springs of the Laach Lake would form a deposit of iron-ochre 33 feet thick over an area of 14 square miles.

All the deposits to which reference has so far been made may be transported to another site by mechanical agencies, or leached out by chemical agencies, and re-deposited. The iron-ores of Salzgitter and Dörnten, north of Goslar, are a good example of purely mechanical redeposition: angular and rounded fragments of brown hæmatite occur there, bound together by a ferruginous cement. The ores are shown to have originated in Jurassic times, and to have been redeposited in the Cretaceous period. Chemical redeposition, of which the limonites and bog iron-ores are salient examples, is of much more frequent occurrence; and there seems to be little doubt that, in former geological periods at all events, iron-ore deposits have been formed at the bottom of the sea, such as those of Cleveland and Lorraine, Kressenberg and Hildesheim.

Nor must the leaching action exerted by springs flowing through rocks rich in iron be forgotten, precipitating later on the iron which they have thus leached out of the rocks, although originally the springs themselves contained no ferruginous particles. Ochreous deposits formed in this manner are to be seen in the Bunter Sandstone district of the Black Forest.

All the iron deposits enumerated above are subject to modification and metamorphosis through the phenomena of tectonic movement (pressure, etc.), decomposition and weathering; and thus it is not always easy to solve the problem of their primary genesis. The following classification is suggested: (1) Primary deposits, including (*a*) magmatic differentiates; (*b*) magmatic lodes; (*c*) pneumatolytic-hydratogenous (contact-deposits); and (*d*) deposits formed from thermal springs. (2) Secondary deposits, including (*a*) those formed by mechanical redeposition; and (*b*) those formed by chemical leaching-out and redeposition. L. L. B.

MAGMATIC SEGREGATION OF IRON-ORES IN GRANITE.

Über magmatische Ausscheidungen von Eisenerz im Granit. *By* J. H. L. Vogt. *Zeitschrift für praktische Geologie*, 1907, *vol. xv., pages* 86-89, *with* 5 *figures in the text.*

The author can only explain satisfactorily to himself the occurrence of deposits of magnetite in several localities in the extensive granite-area of the Lofoten isles, in Northern Norway, on the hypothesis that they are the outcome of a process of magmatic segregation within the granitic magma.

The Lofoten granite, belonging to the fundamental rock-group, is frequently porphyritic, the phenocrysts being orthoclase or microcline; the ferromagnesian silicates are developed in it, either in the form of biotite, or in that of hornblende, and sometimes of both minerals; basic segregates of amphibolite are of frequent occurrence; the silica-percentage averages 70; and, finally, the granite sometimes shows signs of intense compression and sometimes of very little.

At Fiskefjord and in its neighbourhood, on the island of Hindö, within a belt some 6¼ miles long and 2 to 2½ miles broad, there are several hundred distinct magnetite-deposits (reckoning in those of insignificant extent as well as those of some importance). Some 30 miles farther south-west, on Westvaagö and Gimsö, within a belt some 3 miles long and 2 miles broad, there are at least twenty such deposits—a number that could be easily increased to fifty, if small ore-bodies a couple of feet or so in length were included. And these are not the only iron-ore belts within the Lofoten granite-area. They may be generally described as flattish lenticular masses, which occasionally

exceed 820 feet in length and 115 feet in breadth, but are generally of smaller dimensions; and by far the greater number range from 30 feet or thereabouts to 80 feet in length, with a breadth of a couple of yards or so. The bedding-planes of these ore-bodies are sensibly parallel with the structural planes of the enveloping granite.

Morphologically, the iron-ores here described are comparable with the segregations of titaniferous iron-ore in gabbros, labradorite-rocks, augitic and nephelinic syenites, etc.; as also with those of chromite in peridotites, especially in those cases where these rocks have undergone great compression.

In the immediate vicinity of the ore-bodies, the Lofoten granite is markedly rich in magnetite, biotite and hornblende. Although the iron-ore is almost exclusively magnetite, the deposits are of variable mineralogical composition. Thus, in the Fiskefjord area, the magnetite is so commingled with quartz, hornblende, biotite and sometimes garnet, that the crude ore averages only from 35 to 38 per cent. of metallic iron. The ore is here of a highly-schistose structure, resembling in appearance the *torrsten* or hard ore of Sweden. In the Smorten-Jörendal area (Westvaagö and Gimsö), the associates of the magnetite are predominantly hornblende, biotite and pyroxene—quartz and felspar being of sparse occurrence; hereabouts the ore averages 40 to 60 per cent. of metallic iron, and schistose structure is but feebly (if at all) apparent. In other portions of the great Lofoten granite-area geologically similar ore-deposits have been found, averaging from 60 to 65 per cent. of metallic iron. As a rule, some pyrites, and occasionally magnetic pyrites as well, is associated in varying quantity with the magnetite. Apatite is also of variable occurrence: in the Fiskefjord district, the percentage of phosphorus averages 0·2, but is sometimes higher. In one hole, the author saw an apatitic iron-ore, with macroscopically visible apatite, somewhat resembling the Gellivaara ore. In other districts, however, as, for example, Smorten-Jörendal, the percentage of phosphorus in the ore is quite insignificant (0·03 to 0·05). The granitic pegmatite-veins which frequently seam the Lofoten granite are also observed to strike through the ore-bodies.

There is no doubt that these iron-ores were formed at the time of the eruption of the granite, and that they accumulated within the granitic magma by some process of magmatic segregation or differentiation. Perhaps the same hypothesis will explain the origin of the Gellivaara ores, and those of Solberg-Lyngot (Tvedestrand-Arendal). L. L. B.

GENESIS OF PISOLITIC IRON-ORES.

Origine et Mode de Formation des Minerais de Fer Oolithique. *By* Stanislas Meunier. *Comptes-rendus hebdomadaires des Séances de l'Académie des Sciences*, 1906. *vol. cxlii., pages* 855-856.

The author points out that the recently-published researches of Dr. L. Cayeux on the Diélette iron-ore have furnished a most complete confirmation of his own theory as to the origin and mode of formation of pisolitic iron-ore deposits among stratified rocks. His investigations and experiments had long ago satisfied him that these pisolites are the result of the epigenesis of an oolitic limestone. This itself was derived from an ordinary marine calcareous ooze, in which the percolation of subterranean waters had determined the progressive concretion of carbonate of lime around certain nuclei—concurrently with the elimination into the interoolitic spaces of the non-crystallizable and the more especially argillaceous elements of the deposit, which thus formed the cementing-material. He holds that the epigenesis of this oolitic limestone took place long after its deposition, under the influence of waters very weakly

mineralized with salts of iron and salts of aluminium. That is why limonite is always associated with the bauxite which retains the form of oolite after the dissolution of all the iron (that is, by hydrochloric acid).

In the course of his numerous experiments, the author has endeavoured to reproduce the varying particularities of epigenetic phenomena, and he is thus enabled to explain why the deposition of iron does not always take place in a perfectly even manner throughout the entire limestone-mass. The slightest variation in structure is sufficient to cause the ferruginous solutions to flow by certain points without yielding any precipitate, while near by they may be throwing down great quantities of iron. The difference in volume between limonitic oolites and calcareous oolites within strata of the same age is dependent on the difference in density of the two substances; so, too, the flattened form of the ferruginous oolitic granules contrasts with the sphericity of the granules in oolitic limestones.

But the history of the pisolitic iron-ores is only a particular case from among the numerous instances of the change of a calcareous formation into a ferruginous one, and in all these instances the chief structural features have been preserved despite the fundamental alteration in composition. These facts bear eloquent testimony to the unceasing activity of aqueous solutions circulating in the subterranean regions of the earth's crust. L. L. B.

STRATIGRAPHICAL CONDITIONS AFFECTING THE OCCURRENCE OF PETROLEUM.

Einiges über die Lagerungsverhältnisse des Erdöls. *By* A. F. Stahl. *Chemiker-zeitung*, 1906, *vol. xxx.*, *No.* 30, 4 *pages.*

Premising that it is well-known that the largest quantities of petroleum are obtained from the summits of anticlinal folds, where the oil, saturated with gases, is often present in such abundance that it must have been stored up and concentrated, and cannot possibly have originated where it now occurs, the author maintains that it must have formed in the practically horizontal beds of widespread basins, where consequently it was originally distributed over a very extensive area. In such beds, wherein we cannot hope to find either locally great accumulations of petroleum or high tension of gases, bore-holes or sinkings could only meet with scant success. Moreover, the necessity of getting through a great thickness of barren strata, which generally overlie the productive oil-bearing beds, has to be taken into account. It may be postulated that orographic movements, that is, folding of portions of the earth's crust, originated the concentration or accumulation of petroleum. But such movements involved also the bursting up and fissuring of the barren strata, whereby a path was opened to the influence of atmospheric agencies, the final result being that the productive oil-bearing horizons were brought nearer to the surface and rendered more accessible to boring operations.

The author distinguishes, however, between two systems of tectonic plication. With the first, the true orographic or mountain-building folds, are associated merely sporadic petroleum-deposits, the industrial value of which is, to say the least, doubtful. But, with regard to the second, examples of which are patent in the Caucasus and in Persia, where several ranges of foot-hills strike parallel with the great mountain-chains, the case is different. He explains how each elevation here above the average level of the anticlines received an elliptical form, and constituted thereby an eligible reservoir for petroleum. In the course of being folded up into anticlines every kind of rock, except the plastic clays, was inevitably cleft and fissured, such clefts and fissures favouring, of course, the accumulation of oil; and so it often happens

that a bore-hole which luckily penetrates a fissure proves very productive, while another put down close by, but missing the cleft, fails to strike oil at the very same horizon.

Plastic clays are an essential factor in the productivity of petroleum-bearing beds, since they form a hermetic seal closing up the natural reservoirs of oil and gas: they neither allow the latter to escape, nor do they permit the access to them of the destructive agencies of the atmosphere. And thus it is that, where the anticlines are acutely folded, and the strata have been so fissured as to cleave the argillaceous horizons also, little reliance can be placed on either the quantity or the quality of the petroleum that is to be got there.

As to synclinal folds, the author avers that only in exceptional cases could we hope to find productive oil-reservoirs therein. The laws of gravity, remembering that petroleum is generally associated with natural brine, forbid.

In conclusion, it is pointed out that where marls and shales predominate, while conglomerates and sands, if present at all, play a very subordinate part, petroleum of excellent quality, though perhaps in small quantity, may be found.

L. L. B.

TERTIARY COAL-DEPOSITS OF RUDA, DALMATIA.

Das kohlenführende Paläogen von Ruda in Mitteldalmatien. By F. von Kerner. *Verhandlungen der kaiserlich-königlichen geologischen Reichsanstalt*, 1907, *pages* 134-157, *with* 3 *figures in the text.*

Stratigraphical evidence is adduced to show that the utmost extent of the coal-seam of Ruda, in Central Dalmatia, along the strike cannot exceed a mile; and stress is laid upon this point, because in non-geological circles the expectation had been (and perhaps is still) cherished that the seam would be found to extend far eastwards into the foot-hills of the Prolog range and equally far westwards to the margin of the Sinjsko Polje. This delusion has been fostered by the discovery, below the summit of Mount Varda, of a black, combustible, mineral substance which has some external resemblance to the Ruda shaly coal; it is probably, however, a peculiar form of the highly bituminous infiltrations which are locally not uncommon in the Cretaceous limestones of Dalmatia. As to the presumed westward extension, the lignites of poor quality discovered south of Vrdoljak are in no sense identifiable (or even comparable) with the Ruda coal.

The Ruda seam, in common with the strata which overlie and underlie it, dips very steeply; and whether deeper down there is a flattening-out of the dip, or whether the beds have undergone still greater disturbance, the exploration-work so far accomplished has failed to show. Consequently, estimates as to the amount of probably available coal are, to say the least, premature. The hydrographical conditions of the valley are unfavourable to mining operations: most of the coal (whatever be its total, as yet unascertained, amount) lies below the level of the Ruda Potok. That river cuts diagonally through the coal-seam, the floor of which—the calcareous parting between the upper and the lower marly limestones—is easily permeable to water, while these marly limestones themselves are by no means impermeable. Deep workings would, therefore, have to contend with the continual rapid inflow of the great mass of the river-water. Now this river is one of the most important bournes in Dalmatia, arising from a spring which brings to daylight again the numerous streams that disappear underground on the western margin of the Busko plateau, and any attempt to divert its course is economically impracticable. Great engineering works will be necessary, utilizing the river itself for power-purposes, to keep the water out of the prospective deep workings.

The purest black coal from the seam burns well in an open grate, leaving but few cinders; in the process of burning it becomes remarkably soft and coking, and various expert opinions concur in pronouncing it to be a mineral peculiarly suitable for the purposes of gas-manufacture. An officially conducted analysis in Vienna of the dark-grey so-called "coal-shale" (the less pure portion of the seam) yielded the following results: a sample burnt in the open grate left 34·4 per cent. of ash, and the heating capacity amounted to 3,065 calories; a sample submitted to gasification yielded 4 per cent. of hygroscopic water, 45 per cent. of heavy hydrocarbon gases, and 51 per cent. of residues.

The Ruda valley, a narrow glen terminating in a great circular expansion, is the outcome of longitudinal and cross-faulting, and is filled with strata of later age and of easier erosion than the rocks (Cretaceous limestones and dolomites) which hem it in. The younger strata are assignable to the Eocene and early Oligocene divisions of the Tertiary system, and, consisting largely of limestones, limestone-conglomerates and flaggy calcareous marls, may be separated into three groups, at the base of the uppermost of which lies the coal-seam. This rests upon a marly, much-fissured limestone, full of *Chara*-seeds and fossil freshwater mollusca. The seam, taken as a whole, is several feet thick, but consists of various bands of pure black coal and dark-grey coal-shale separated by marly partings. The immediate roof is a thinly flaggy, marly limestone, wherein fragments of the branches of a fossil conifer (*Araucarites*) and impressions of leaves (such as *Dryandra*) are of tolerably frequent occurrence. This roof, which is bereft of even a trace of coal, is overlain by a lithologically similar stratum with which, however, are interbedded several vennles of coal-shale each barely an inch thick. The Ruda coal-flora includes twenty-three species of definitely-determined plants, and perhaps another score the attribution of which is uncertain: it points to the late Eocene or early Oligocene age of the beds; and the probability is, that in this region the Tertiary floras were slower to change than the corresponding faunas.

The tectonic structure and the stratigraphy of the Ruda valley are described at considerable length, this description forming perhaps the greater bulk of the paper. L. L. B.

CARBONIFEROUS MARINE STRATA IN HUNGARY.

Das Marine Karbon in Ungarn. By Fritz Frech. *Földtani Közlöny*, 1906, *vol. xxxvi., pages* 103-154, *with* 3 *figures in the text and* 9 *plates.*

The author describes and figures, first of all, three species of brachiopods and two of corals from Kornyaréva in southern Hungary, the only locality in the southern Carpathians where Lower Carboniferous rocks are so far known to occur. He then proceeds to describe and (in most cases) figure fourteen species of brachiopods, four of lamellibranchs, seven of gasteropods, three of trilobites and two of corals, from the Nœtsch beds of Dobsina or Dobschau, remarking by the way that the material is mostly in a very bad state of preservation. He assigns the age of the Kornyaréva beds to the upper division of the Lower Carboniferous (Visćen); with regard to the Dobsina rocks, which also belong to that upper division, he shows what forms are common to the Nœtsch beds and to those of Carinthia and Styria, and also what forms are common to the Lower Carboniferous of Silesia. Except for the occurrence of cephalopods in the last-named province, the character of the faunas, as well as the lithology of the rocks, indicates in all these cases deposition in comparatively shallow waters. A further comparison is made with the Lower Carboniferous of Sarayevo in Bosnia and with that of Asia.

In conclusion, the author points out that, hitherto, no fossils of Lower

Carboniferous age had been definitely determined from Hungary, or from the southern and eastern districts of the Balkanic peninsula. The Kornyaréva and Dobsina beds are the oldest fossiliferous deposits in the Carpathian region of Hungary, and to their occurrence attaches an interesting possibility: namely, that somewhere in this region, amid the folds of the older Palæozoic strata, plicated in Carboniferous times, a mass of productive Coal-measures lies hidden away under a cover of younger sediments. This would approximate to what is the normal condition of things in the Carboniferous areas of Central and Western Europe. L. L. B.

PETROLEUM-BEARING ROCKS OF KOMARNIK-MIKOVA AND LUH, HUNGARY.

Über die Petroleumvorkommen von Komarnik-Mikova und Luh. By Julius Noth. *Földtani Közlöny*, 1907, *vol. xxxvii., pages* 99-104, *with a map and section in the text.*

In three of the ranges of hills belonging to the Carpathian mountain-system, which strike across the frontier southward from Galicia into Hungary, the occurrence of petroleum has now been definitely proved. At Körösmezö, in Máramaros county, the conditions of the occurrence differ in some respects from those observed in the Galician deposits; but at Luh and Komarnik-Mikova in the neighbouring counties, the similarity with Galician conditions is unmistakable, as regards both the tectonic features and the lithological composition of the oil-bearing rocks. Sandstones of Cretaceous age rich in calcite, are followed by red and mottled fucoidal marls, and these again by Nummulitic calcareous sandstones. In the north-east of the area described, mottled clays overlie fine-grained sandstones strongly impregnated with oil; upon them rest greenish and bluish fucoid-beds and finally Menilite-slates, which in places have a capping of Magura sandstone. The range of hills constituting the oil-belt and consisting of the rocks just described is traceable from Polany, through Ropianka and Barwinek (all well-known Galician localities), south-eastward across the Hungarian border to beyond Komarnik. The place where oil was struck at Barwinek is hardly 1¼ miles distant from the Hungarian border, which is there a gently-sloping divide or watershed some 1,650 feet above sea-level. At Mikova, 18½ miles within Hungarian territory, several barrels of oil were got from a shaft 59 feet deep, sunk through similar rocks. The author observes that the most hopeful-looking traces of petroleum farther in the interior of Hungary can hardly afford the same chances of success to the capitalist prepared to bore for oil, as localities such as those mentioned, which lie comparatively so near the great Galician oil-field.

At Luh, in Ung county, spasmodic attempts at working the petroleum-bearing beds have been made at various times, but apparently without a right regard for the structure and stratification of the rocks; and, moreover, the explorers did not go deep enough down. The author points out that the anticline seen at the Government bore-holes and 300 feet or so upstream from the bridge over the Ung river, consists of a compressed fold of Menilite-slates; from these, gas-emanations arise, oil oozes out, and they also contain small quantities of excellent ozokerite (although not sufficient, apparently, for industrial purposes). Sand-stones predominate northward and north-eastward, and the steeply-inclined strata flatten out; and so ¼ mile above the bridge, conformably overlying sandstones are seen which are undoubtedly of Oligocene age (Magura sandstone). Some 1,650 feet downstream from the same bridge the complex of strata (red and mottled marls, fucoidal shales, etc.) comes in, similar to the beds which in many localities in Galicia are rich in petroleum;

and it is in these, rather than in the Menilite-slates, that boring operations are likely to prove fruitful. For, if all the oil hitherto struck at Luh is really associated with the Menilite-slates, payable quantities are not to be expected, as such petroleum as those beds contain is mere leakage from the older (Eocene) red marls, etc. L. L. B.

PETROLEUM- AND OZOKERITE-DEPOSITS OF BORYSLAW, GALICIA.

Boryslaw: une Monographie géologique. By J. Grzybowski. *Bulletin International de l'Académie des Sciences de Cracovie*, 1907, *pages* 87-124 *and* 2 *plates.*

Natural exposures in the oil-bearing and ozokerite-belt around Boryslaw are so scarce, that, in order to gain a real insight into the tectonic structure of that supremely interesting district, geologists have to pursue their investigations along a considerable extent of the marginal zone of the Carpathians. Some of the best exposures are seen in the Nahujowice valley, 5 miles to the west, also in the Jasienica, Popiele and Tyśmienica valleys, and near Tustanowice and Truskawiec. The strata are briefly described, and appear to consist chiefly of an alternation of soft glauconitic sandstones, with brown and grey shales and clays and occasional conglomerates.

The entire second chapter of the memoir is devoted to the stratigraphy of the marginal zone of the Carpathians, and the author tabulates the rock-succession at Boryslaw as follows, his conclusions being strengthened by recent fossil-finds:—The highly-contorted *Inoceramus*-beds (Ropianka beds) of Upper Cretaceous age are overlain by massive Jamna sandstones (possibly Cretaceous, but more probably Eocene). To these succeed the Hieroglyphic sandstones (among which are intercalated thin bands of red and grey clay) and sandy marl-slates of undoubted Eocene age; upon which follow the Menilite-slates (the lower portion of these being very cherty) and the Dobrotow sandstones and shales of Lower Oligocene age. Then follows an unconformity, the entire series being capped by the Miocene saline clays (first Mediterranean stage). The ozokerite-deposits now worked occur in the Dobrotow group. There is a grey, slightly marly, unbedded shaly material known as *sytyca*, which in the north-eastern area of the ozokerite-workings, goes down to depths of 170 and 200 feet; its petrographical characters assimilate it to the ejectamenta of many mud-volcanoes, and in all probability it is in fact the product of long-extinct mud-volcanoes which must have been active at some epoch previous to the last orographic movements to which the region has been subjected.

The ozokerite-veins generally have a steep dip, and their limiting-surfaces, especially at the foot-wall, are smooth and black as if varnished. The infilling consists of fragments of the country-rock with which the ozokerite is intermingled; although the latter often occurs independently in big lumps, and tends indeed to accumulate at either wall of the vein. Crystals of rock-salt are frequently associated with it. The author distinguishes between (*a*) simple and (*b*) compound veins. The former are generally of no great thickness, while the latter in groups of thin parallel veins often attain a thickness of 100 feet or so. Occasionally the veins bifurcate, and on passing, say, from a tough into a soft rock-formation they may be seen to form stringers and secondary or lateral veins. These stringers, forming layers of pure ozokerite along the bedding-planes some feet distant from the principal vein, are termed by the Boryslaw miners *plazowka* or flat veins. According to the strike, the veins may also be classified as longitudinal and transverse veins respectively,

the former striking almost parallel with the country-rock, and the others almost perpendicular thereto. The principal longitudinal vein now worked dips 65 degrees northward, strikes between west-north-west and west, thins out and becomes impoverished towards the south-east while it broadens out and becomes richer towards the north-west. It is cut across by several transverse veins, some of which are of considerable importance. The veins are evidently the infilling of fissures opened up in a highly dislocated mass of strata.

The petroleum-deposits so far explored in this district extend over a length of $1\frac{3}{4}$ miles (not including Tustanowice) from north-west to south-east, and over a breadth of little short of a mile. The productive oil-field is cut off on the north-west by the Ratoczyna valley, beyond which the oil-bearing strata (but no appreciable quantity of oil) have been struck in various borings. The north-eastern and south-eastern boundaries of the oil-field have been determined with some precision, but its south-western limit (towards the mountains) has not yet been definitely ascertained. The strata pierced through by the bore-holes, details of fifteen of which are tabulated, are predominantly grey and brown shales alternating with grey to greenish fine-grained sandstones, with occasional bands of conglomerate. Basing his conclusions on the results, however, of no less than 160 borings, the author points out that the principal oil-horizon (petroliferous sandstone) occurs among or below the deeper-lying black-shales of the Dobrotow group. This horizon dips towards the middle of the field some 20 degrees southward, from a depth of (say) 2,000 feet below the surface to 2,600 feet or more; and farther south it suddenly drops to a depth of 3,300 feet, but still farther south again is struck at somewhat shallower depths. Several oil-horizons of variable productiveness are recognized at Boryslaw above this principal one, this variability having probably something to do with the fissuring of the strata to which reference has already been made. It may be added that the author agrees with the view that the ozokerite was originally derived from the petroleum.

The fifth chapter deals mainly with the tectonics of the area, a study of which leads to the following inferences: (*a*) that bore-holes put down farther south, at all events within the area of the Hieroglyphic sandstones, may possibly reach at greater depths the Boryslaw oil-bearing beds; and (*b*) if Menilitic cherts are struck, which is to be expected in the course of boring for the deep-lying petroliferous beds, the presence of water in the Menilite-slates need not be feared. Two great overthrust faults have been proved in the marginal or foot-hill ranges near Boryslaw, of which the northernmost is the older, and has conditioned the later earth-movements. This points to sagging having taken place before the deposition of the Miocene saline clays; but earth-movements probably continued long enough to cause the advance of the Miocene sea over the broken-down margin of the Carpathians.

The memoir concludes with a series of ten analyses (results of fractional distillation) of the petroleum from six different workings.

L. L. B.

PYRITIC DEPOSITS OF KAZANESD, HUNGARY.

Neuere Daten zu den geologischen Verhältnissen der Umgebung der Schwefelkiesgrube in Kazanesd. By Anton Lackner. *Földtani Közlöny*, 1906, *vol. xxxvi., pages* 352-358, *with a map in the text.*

The pyrites-mine of Kazanesd lies amid an area of eruptive rocks, and it is only at a distance of some few miles that limestone-reefs crop out. The matrix-rock at the mine is a greenish-blue diabase with uralitized augite, and, in nearly every hand-specimen, eyes of pyrites occur. Dykes of quartz-

porphyry and granodiorite are intruded into this diabase (which covers a vast area) at many localities, including the mine itself. The granodiorite is quarried for building-stone, and dykes of it traverse a gabbro which also occurs in the neighbourhood of the mine.

At the Miklós shaft, in the Tataroja valley, upstream from Kazanesd, lodes of copper-ore 12 to 16 inches thick, striking east and west, are known to occur, and in the immediate vicinity are traces of ancient workings where the author, however, found only very thin metalliferous lodes.

The question as to whether the gabbro above mentioned is a dyke-rock or a deep-seated eruptive is of more importance than would at first sight appear. Dr. Karl von Papp inclines to the latter view, and the author agrees with him; but Mr. Messena held that the gabbro had broken through the diabase in dyke-like masses, followed at later periods by the quartz-porphyry, and finally by the granodiorite. Admitting that the diabase dates from Triassic time, the gabbro would then have been erupted in company with the melaphyres in the Jurassic period, the quartz-porphyry in the Cretaceous, and the granodiorite in the latest Cretaceous or more probably the Tertiary period. And, as a consequence, the metalliferous ores would date from several different periods.

The author adduces reasons, however, for considering that the gabbro is really the oldest rock in the area, and that it was succeeded by the diabase. The great masses of pyrites mined at Kazanesd are possibly of magmatic origin; but the action of the quartz-porphyry eruptions had in all probability much to do with the formation of the ores there, as also in the cupriferous lodes, which are quite distinct from the stockworks of pyrites. Such lodes traverse both the gabbro and the diabase (although containing but little ore in the latter), and are probably the infilling of fissures which were opened up in the rocks at the time of the diabase-eruptions or perhaps even later.

Some 600 feet away from the mining settlement, the Petrosza valley branches off from the Tataroja valley, and here recent railway-cuttings have exposed the diabase and a quartz-porphyry dyke veined with pyrites; in all probability, this is the very same dyke that is found to be cupriferous in the Pozsorit mines in a neighbouring valley, and it strikes therefore right across from one to the other. In the Kaprilor valley, parallel with that of Tataroja, copper-ores were at one time actively worked in rocks similar to those above described, but, owing to insufficient output, mining operations have now been suspended there. The cupriferous lodes in the gabbro-area of Almasel are geologically similar to the occurrences in the Kaprilor valley, and have been opened up by a French company. It is found that there the lodes become richer in depth, and thus it seems possible that the Kaprilor lodes also might yet repay working; but the cost of further exploration-work would be heavy.

L. L. B.

COPPER-ORES AND WOLFRAM-ORES IN SOUTHERN TYROL.

Ueber das Vorkommen von Kupfererzen und Scheelit im Eruptivgestein von Predazzo und anderen Orten. By J. Block. *Sitzungsberichte der Niederrheinischen Gesellschaft für Natur- und Heilkunde zu Bonn*, 1905, *pages* A68-A82.

The neighbourhood of Predazzo was, at some period later than the Trias, a centre of vulcanicity to which the granites, porphyrites, melaphyres and monzonites of Monte Mulatto (7,055 feet) bear eloquent testimony. On this mountain, as on Monte Malgola, which towers above Predazzo to the south-east, copper- and iron-pyrites and magnetite occur in considerable quantity. The last mentioned ore was at one time worked on the eastern flank of Monte

Mulatto, at an altitude of 5,170 feet. On the northern flank of the same mountain, from the height of 5,250 feet up to the summit much exploration-work appears to have been attempted in the chalcopyrite-deposits. The Bedovina mine on the western flank has been opened up in a shatter-belt of melaphyre (5 feet broad) consisting of narrow fissure-veins, some of which are parallel one to the other, while others intersect. These veins are mineralized with chalcopyrite, iron-pyrites, some malachite, scheelite (tungsten), etc. The wolfram-ore is again noted, amid stellate aggregates of tourmaline associated with fluorspar, in the tourmaline-granite quarries upstream from Predazzo, on the right bank of the Avisio. A rare associate is arsenical pyrites. The scheelite is of coarse texture, presents a greasy lustre, and a pale pea-yellow colour. There appears to be no question of the genetic analogy between those Monte-Mulatto ores and tinstone or cassiterite-veins. The copper-ores, just as those of Rammelsberg and Rio Tinto, average 2 to 3 per cent. of metallic copper; but the association of scheelite with them (as at Monte Mulatto) is an uncommon occurrence, and is of some industrial importance. Remembering that the metals of the wolfram- and vanadium-groups generally concentrate in acidic eruptive magmas, we may perhaps invoke the conjunction of acidic and basic eruptives in the district here described, as furnishing in part the explanation of so rare an association.

The marbles and serpentine-rock of the district are described at some length. L. L. B.

FORMATION OF THE BELGIAN COAL-MEASURES.

Observations paléontologiques sur le Mode de Formation du Terrain houiller belge. *By* A. Renier. *Annales de la Société géologique de Belgique*, 1905, *vol. xxxii., Mémoires, pages* 261-314, *with* 11 *figures in the text and* 1 *plate.*

In the first chapter the author discusses the significance of the terms "roof" and "floor" in relation to coal-seams, and points out that the miner is more apt to differentiate the roof from the floor by their respective lithological and palæobotanical characters than by their stratigraphical position. Yet it is manifest that here stratigraphy plays quite as important a part as lithology and palæontology. Generally speaking, the roof is characterized by the absence of *Stigmaria* (except as débris) the rootlets of which usually occur entire in the floor; and the fracture of the former is more regular, more coincident with the bedding-planes than the fracture of the latter, in which every fossilized rootlet constitutes a surface of least resistance—yielding more readily to the blow of the pick or to the tension developed by folding. Some miners, and with them some geologists, are prone to restrict the designation "floor" to the under-clay so well known to the British miners. But this restriction will not square with all the facts: there are cases where the true floor may be a sandy shale, or even a grit. Similarly, the lithology of the roofs of coal-seams is more variable than the average miner is willing to admit; such a thing does occur as a grit-roof, devoid of any traces of regular bedding.

The author lays down, as a general axiom, that one of the principal distinctions between a floor and a roof resides in the state of preservation of the fossils which occur therein. In the roof they are found in a disintegrated condition; in the floor they are preserved entire. He lays very great stress on this point, and marshals the evidence in favour of it at considerable length. It is noticeable that, while entire *Stigmaria* occur indifferently in every kind of floor, the fossils characteristic of the roof vary according to the mineralogical composition of the sediments in which they are involved. The author regards the plant-remains found in roofs as drift-material which has not, at all events

in every case, been necessarily floated from any great distance; while he regards the entire *Stigmaria* as having undergone fossilization at the spot where they grew, and therefore that the floor originally constituted in every case a vegetable soil (or plane of plant-growth, if that term be permissible). The fact that the appendices of the *Stigmaria* are often directed obliquely or vertically upwards as well as downwards leads him to suggest that they penetrated after the fashion of rhizomes into a mud that had already been laid down.

There is another aspect of the question, to which so far little attention seems to have been devoted. The author figures and describes in detail instances of the penetration by the rootlets of *Stigmaria* of those disintegrated plant-remains which are known to occur in the roofs of coal-seams. He arrives at the conclusion that all barren strata in the Coal-measures are "roof"; consequently, that the roof as thus defined has no special mineralogical nor any essential palæontological characteristic, although it often contains disintegrated plant-remains. When it has been transformed by the superimposition or implantation within it of vegetation (chiefly *Stigmaria*) it becomes a floor. Wherefore a floor may contain the fossil impressions supposedly characteristic of a roof, since it is in many cases nought but an altered roof; and, for the same reason, a "floor" may become the roof of a coal-seam, but only when the parting between it and the next seam is inferior in thickness to the transformed layer or stratum.

The second chapter is devoted to the investigation of the occurrence of more or less erect trunks of fossil trees in the Belgian Coal-measures. Fresh discoveries of these have been accumulating within recent years, but they do not always furnish incontrovertible proof of vegetation *in situ*, since it has been shown that drift-wood may occur in an erect position within the sedimentary deposits. The finer grained and the more clayey is the sediment at the base of such a trunk, the greater is the chance that the tree grew where we now find it; but this opinion is almost converted into certainty if a number of delicate rootlets are observed in undoubted connexion with the trunk. The difficulty of ascertaining this in every case, however, impels us to cast about for other accessory proofs. One has, of course, to be on one's guard against the possibility that a trunk with roots and all has been washed bodily away from its original habitat. Indeed, most Belgian geologists who have described the erect trunks found in their Coal-measures are, to judge from the passages quoted in this chapter, inclined to disbelieve in the trees having grown where they now occur; but the author argues with great persistence and plausibility against the drift-wood theory in almost every case.

In his third chapter, he begins with the statement that the formation of the Coal-measures is the result of the repetition of the cycle:—floor, coal-seam, roof, . . . floor, except perhaps in the case of certain cannel-coals. He regards an ordinary coal-seam as the result of the putrefaction in place and under water of several varieties of plants, and probably (though in a smaller proportion) of some animal organisms. The hypothesis that coal-seams have been built up by the continuous superimposition of forests on deposits which were in process of conversion into peat, does not exclude the probability that some of the constituents were drifted. In fact, the occurrence of rolled pebbles actually within the coal, proves that there must have been drifted vegetable material which by its comparative lightness could act as the carrier of these pebbles. It seems probable that the area wherein the Belgian Coal-measures were being deposited was at that time physiographically featureless; and, in this connexion, it may be recollected that palæobotanists have shown that

Stigmaria could not have flourished under a greater depth of water than 16 feet or thereabouts.

A bibliographical list consisting of twenty-nine entries is appended to this very exhaustive paper. L. L. B.

A MARINE BAND IN THE CHARLEROI COAL-MEASURES, BELGIUM.

Découverte, dans le Terrain houiller supérieur de Charleroi, d'un nouvel Horizon fossilifère marin (le plus élevé). By René Cambier. *Bulletin de la Société belge de Géologie, de Paléontologie et d'Hydrologie*, 1906, *vol. xx., Procès-verbaux, pages* 169-171.

Prof. X. Stainier, in his great monograph on the Coal-measures of Charleroi and the Lower Sambre, had cited, as the uppermost band containing a distinctly pelagic fauna, an horizon some 100 feet above the roof of the Sainte-Barbe seam of Floriffoux, yielding *Lingula mytiloides* and scales of *Elonichthys*. Recently, however, the author has found *Lingula mytiloides* in No. 12 pit of the Charbonnages Réunis, at Charleroi, about 20 feet below the Duchesse or Naye-à-Bois seam; that is, 1,476 feet above the highest horizon at which that *Lingula* had been hitherto recorded in the Charleroi basin.

The floor of the Duchesse seam is, at this locality, rather gritty in character; it passes downward very gradually into a sandy shale; thence into a grey shale; and finally into a very characteristic grey-striped black shale, which breaks up into long parallelipipeds and is more or less regularly interbanded with thin clay-ironstones. *Lingula mytiloides* occurs in great abundance in this shale, in two varieties, the smaller and most abundant of which exhibits some resemblance with *Lingula parallela* of Prof. John Phillips. Throughout the entire thickness of the shale, but more especially near the bottom and near the top, *Carbonicola subrotunda* is found. A fish-scale has been obtained, belonging apparently to the genus *Rhizodopsis*. Some vegetable débris, much comminuted, also occur; they are, very evidently, drifted material.

This newly-discovered marine-band facilitates the correlation of the Liége Coal-measures with those of Charleroi, and constitutes another presumption in favour of the contemporaneity of the two basins. L. L. B.

FAUNA AND FLORA OF THE LOWER COAL-MEASURES OF BAUDOUR, HAINAUT.

(1) *Sur la Faune du Terrain houiller inférieur de Baudour (Hainaut).* By J. Cornet. *Comptes-rendus hebdomadaires des Séances de l'Académie des Sciences*, 1906, *vol. cxlii., pages* 734-736.

At the Baudour colliery, near Mons, two tunnels have been in progress during the past five years, for the purpose of reaching the productive Coal-measures without going through the Cretaceous covering rocks; the tunnels are driven at an inclination of 25 degrees to the southward, and that one with which the greatest progress had been made had (at the time of publication) attained a length of 3,050 feet, at a depth of 1,217 feet below the surface. The strata dip generally at about the same inclination as the tunnel; but, on account of secondary undulations and a succession of faults, it has been possible to investigate an ascertained thickness of 140 feet or so of deposits belonging to the barren series (catalogued as H_{1a} by the Belgian Geological Survey) which intervenes between the Carboniferous Limestone of Hainaut and the lowermost coal-bearing measures of the Mons basin. This series is the probable equivalent of the Chokier ampelite of the Liége basin, well known for its calcareous nodules full of goniatites. At Baudour, something like 70

species of fishes, cephalopods, lamellibranchs, brachiopods, etc., have been identified, and permit of the correlation of these barren beds with the Pendleside series of British geologists (placed by Dr. Wheelton Hind at the base of the Lancashire Coal-measures, below the Millstone Grit). The specimens of *Posidoniella* at Baudour are remarkably abundant, encrusting the shaly layers in myriads; occasionally they are massed together on plant-remains or on the tests of Orthocerata.

2) *Sur la Flore du Terrain houiller inférieur de Baudour (Hainaut).* By ARMAND RENIER. *Comptes-rendus hebdomadaires des Séances de l'Académie des Sciences*, 1906, *vol. cxliii.*, *pages* 736-738.

The flora of this barren group was but little known hitherto, and the collections made at Baudour have enabled Mr. Renier to draw up a list of 39 undoubted species of plants, to which he expects to add at least a dozen others ere long. These include a great number of ferns, also several species of *Lepidodendron*, *Calamites*, *Rhabdocarpus*, *Trigonocarpus*, etc. Westphalian forms are comparatively rare in this flora, the main features of which are characteristic of the Culm ('Primäre Carbonflora' of Dr. H. Potonié). It is a flora which is certainly much older than that of Zone A (established by Prof. R. Zeiller in the Valenciennes coal-basin) and is easily distinguishable from it, a point which the author holds to be of great practical importance.

L. L. B.

LOWER DIVISION OF THE LIÉGE COAL-MEASURES, BELGIUM.

Note sur la Zone inférieure du Terrain Houiller de Liége. By P. FOURMARIER. *Annales de la Société géologique de Belgique*, 1906, *vol. xxxiii.*, *Mémoires*, *pages* 17-20 *and a table.*

The author separates the Liége Coal-measures into two great divisions, the lower of which is characterized by the absence, or, at all events, the great scarcity of any forms of *Neuropteris* other than *Neuropteris Schlehani* of Stur, and by the presence of a zone of *Sphenopteris Haninghausi* near the top. The upper division, on the other hand, is characterized by the abundance of other forms of *Neuropteris* than *Neuropteris Schlehani*, as, for example, *Neuropteris gigantea*, *Neuropteris heterophylla*, *Neuropteris obliqua*, *Neuropteris flexuosa*, with *Neuropteris tenuifolia* and *Neuropteris rarinervis* near the top. He has now been enabled, by the discovery at the Six-Bonniers colliery in the Seraing district, of a band with big nodules containing undoubtedly marine fossils (*Goniatites* and *Lingula mytiloides*) to correlate these measures with those of the Herve basin, where a similar marine band, full of nodules containing *Gastrioceras Listeri*, *Pterinopecten* and *Orthoceras*, is known to occur. Taking the marine band in each case as the starting-point, the succession of the strata is remarkably similar in the Seraing and Herve districts. But the author goes further than this, and assimilates tentatively the succession at Herstal with that just mentioned. He points out, however, that in certain parts of the Liége coal-field, there is so much variation, both in the composition and in the succession of the coal-seams, that he would be a bold man who would claim to trace every seam and venule throughout the basin.

In his table, therefore, the author does not wish to indicate absolute synonimity of the strata, but to compare synchronous horizons, this being the most important matter for the mining engineer, whose chief desire must be to know whether there is still a great thickness of Coal-measures below the seams that he is working.

L. L. B.

MARINE BANDS IN THE UPPER COAL-MEASURES OF MONS, BELGIUM.

Note sur des Lits à Fossiles marins rencontrés dans le Houiller supérieur (H_2) au Charbonnage du Nord-du-Flénu, à Ghlin. By J. Cornet. *Annales de la Société géologique de Belgique*, 1906, *vol. xxxiii., Mémoires, pages* 35-39.

A drift lately started in a northerly direction, at the 1,690 feet level of the Nord-du-Flénu colliery at Ghlin, has penetrated a hitherto completely unknown portion of the *couchant de Mons* coal-basin. Here, at two horizons, 28 feet apart, such well-known brachiopods have been found as *Spirifer bisulcatus* and *Productus carbonarius*. The uppermost horizon is in a greyish-blue, soft, unaltered shale of fine texture, of the ordinary type of Coal-measure shale. In addition to the brachiopods already mentioned, it has yielded *Orthis resupinata*, *Athyris planosulcata*, *Pterinopecten papyraceus*, and *Lingula (?)*. It overlies a crushed carbonaceous shale with irregular vennles of coal (a pinched-out coal-seam?), about 2 feet thick; the greyish-blue shale above-mentioned has a thickness of 30 feet, and the marine band occurs near the base of it. The lower horizon is in a greyish-blue to black, somewhat altered shale, of coarse texture and varying toughness, slightly over 2½ feet thick, and has yielded *Chonetes laguessiana*, besides the two brachiopods first mentioned. Generally speaking, all these fossils are in good preservation, uncrushed, and easily determinable.

The stratigraphical equivalent of these marine bands (high above the Coal-measure conglomerate) would be the roof of the Sainte-Barbe seam of Florifoux (No. 61 horizon of Prof. X. Stainier), although their fauna recalls that found by Messrs. C. Blanchard and J. Smeysters, at the Forte-Taille colliery, below the Coal-measure conglomerate (No. 69 horizon of Prof. X. Stainier). The Ghlin marine bands cannot be correlated with any of the fossiliferous horizons previously recorded by Messrs. F. L. Cornet and A. Briart, as they occur among strata which neither crop out at the surface nor had ever yet been reached in underground workings. The author assumes further that his readers will not for a moment confound these marine bands with the stratigraphically much higher *Carbonicola*-bands recorded by the late Mr. A. de Vaux at the same colliery of Nord-du-Flénu, at the respective depths of 1,518 feet in No. 1 pit and 1,555 feet in No. 2 pit. L. L. B.

CAMPINE COAL-FIELD, BELGIUM.

Étude géologique des Sondages exécutés en Campine et dans les Régions avoisinantes. By M. Lohest, A. Habets *and* H. Forir. *Annales de la Société géologique de Belgique*, 1902-1903, *vol. xxx., Mémoires, pages* 101-678 *and* 15 *plates.*

For reasons assigned at the commencement of the third chapter of this great memoir, its completion has involved three years' additional work, beyond what had been foreseen when the first two chapters saw the light in July, 1903, and January, 1904.

An analytical bibliography of the subject, involving a critical review of no less than 189 separate works, occupies more than 160 pages (first chapter and appendix) and deals with matter published as recently as August, 1906.

The second chapter is devoted to a brief discussion of the probable limits of the newly-discovered North Belgian coal-field. In this connexion, the Hasselt and Kessel bore-holes are of primary importance. At Hasselt, the Silnro-Cambrian rocks were struck, banishing all hope of finding in that neighbourhood the prolongation of the Coal-measure syncline of Dutch Limburg, and the junction between the older and the newer Belgian coal-fields. At

Kessel, the bore-hole first entered the Carboniferous Limestone, then penetrated the Devonian rocks, and was stopped on the verge of, if not actually within, the Cambro-Silurian. At Lanaeken, too, after a few feet of the very lowest Coal-measures had been passed through, the Carboniferous Limestone was struck. Now, these industrially barren results at all events solve the problem of the southern boundary of the new coal-field: the subterranean trend of the Carboniferous Limestone is approximately indicated by a straight line drawn from Kessel to Lanaeken. Further, it seems probable that the axis of the Campine basin is deflected southward between those two points so as to coincide with the general trend of the main folds of the Namur basin, and the southern boundary of the Coal-measures probably follows to some extent the same trend. Moreover, the palæontological and palæobotanical evidence confirms the mineralogical and lithological evidence, which in its turn agrees with the deductions drawn from the general stratigraphy, the whole furnishing a remarkable instance of concordance between the results achieved by several investigators working independently along different lines of research.

The resemblances between the Carboniferous Limestone of Kessel and that of Yorkshire appear to the authors to furnish an additional confirmation of the hypothesis previously put forward of a correlation between the two coal-fields.

In the third chapter and its appendix, occupying 253 pages, a detailed account is given of the sections proved by 65 bore-holes in Belgium, 88 bore-holes in Dutch Limburg, and 69 bore-holes in the neighbouring German territory. In the last-named sixty-nine, although the Coal-measures were struck in nearly every case, only twice are coal-seams mentioned; but lignite was found in the newer strata overlying the Coal-measures in 24 instances. On the other hand, coal-seams in the Coal-measures were struck in 56 of the Dutch, and in 55 of the Belgian, borings.

The fourth chapter deals with the subterranean orography of the Palæozoic and the Red [Permo-Triassic?] Rocks. Speaking generally, this buried surface in the Campine constitutes a peneplain dipping very gently north-north-eastward or northward; while in Dutch Limburg and the neighbouring German territory it is extraordinarily rugged, presenting deeply-cut, steep-sided valleys, separated one from the other by precipitous ridges. On careful investigation, these prove to have a general south-easterly and north-westerly trend, and are really due to a series of parallel faults; not, as might be at first thought, to the agencies of erosion.

A general description of the Coal-measures, as they occur in the area under review, supplemented by synoptical tables, forms the fifth chapter. A barren zone (*IIb* in the sections) is traceable from the west of the Campine into Dutch Limburg, and makes a fairly good horizon for purposes of classification, despite its variable thickness (282 to 623 feet). Below these barren measures, coal-seams are of infrequent occurrence, occasionally interbedded with shales, and the percentage of volatile matter in the coal never exceeds 26. The deeper down the bore-hole is pushed below the barren measures the farther apart are the seams met with, and their volatile matter diminishes *pari passu*; the average thickness of the 68 workable seams struck in Belgium is $2\frac{1}{4}$ feet, while that of the 85 struck in Dutch Limburg is $3\frac{1}{4}$ feet. Whence it may be inferred that the seams increase in thickness from west to east. These Lower Coal-measures in the Campine attain a known thickness of 14,317 feet, 154 feet of which are workable coal; in Dutch Limburg, out of a proved thickness of 13,809 feet of equivalent strata, 279 feet are workable coal. The

direct superposition of the lowermost Coal-measures on Upper Devonian rocks, in one or two localities, recalls similar occurrences in Shropshire and Staffordshire, where the Carboniferous Limestone is wanting and Coal-measures are seen to rest immediately upon Cambro-Silurian or upon Devonian formations.

The Coal-measures above the barren zone are industrially by far the most important in the Campine, and have been the most actively explored. The percentage of volatile matter in the coal ranges from a minimum of 20·2 to a maximum of 47·1. Generally speaking, this percentage diminishes, though slowly, as the depth increases. In the middle and upper portions of the series, the seams are very numerous and mostly interbedded with shales. It is noticeable also that, amid a group of coal-seams exhibiting the normal downward diminution of volatile matter, a seam will suddenly make its appearance with a percentage of volatile matter far higher than those of neighbouring seams: this implies the occurrence of cannel-coals. In a proved thickness (in the Campine) of 23,544 feet of such measures, no less than 262 seams exceeding 16 inches in individual thickness were passed through, without counting innumerable thinner seams, the total thickness of workable coal amounting to 765 feet. In Dutch Limburg, the uppermost portion of this division of the Coal-measures does not appear to have been explored as yet, and in a proved thickness of 6,221 feet of strata 73 workable seams were struck, yielding a total of 179 feet of workable coal. The percentage of volatile matter ranges from 17·2 at Wolfshagen to 40 at Huis-Doenrade. Ten important faults are named in the synoptical tables, and from the maps and sections the Campine Coal-measures are seen to form two shallow synclines separated by a rather flattened anticline. In Dutch Limburg, the existence of a more southerly syncline even than that of the Southern Campine is to be inferred; the central of the three synclines is the one that has been most thoroughly explored, but a certain northward sweep of the strata revealed by the Gheel borings prefigures the discovery of a fourth and northernmost syncline in the direction of Antwerp. Wherever the Coal-measures have been struck in the region described the dip has proved to be slight; it increases southward, from the neighbourhood of the outcrop of the barren zone onward, and increases still more markedly as the Carboniferous Limestone is approached.

The sixth chapter embraces the preliminary results of more than four years of patient investigation of the petrography and palæontology of the Coal-measures of the region. A microscopic description is given of four specimens of coal, from Kattenberg, Lanklaer, Meeswijck and Eikenberg respectively, and these specimens are defined as sporo-pollinic cannel-coal. Numerous and, usually, well-preserved fossils have been obtained from the bore-hole cores, and a complete list (with localities) is given. All the plant-remains belong apparently to the Westphalian stage, not a single vegetable fossil of clearly Stephanian type having been found. The abundance of *Linopteris obliqua*, *Neuropteris tenuifolia*, with *Sphenophyllum myriophyllum* and *Annularia sphenophylloides*, justifies the inference that these North Belgian Coal-measures include beds of Upper Westphalian age, and are perhaps predominantly of that and of Middle Westphalian age. Generally speaking, the measures belonging to the upper group in this area are light in colour, while those of the lower group are dark.

In the seventh chapter, the covering strata are dealt with at great length: these include the Red [Permo-Triassic?] Rocks, Senonian and Maestrichtian (Cretaceous) beds, and a series of Tertiary (among which the Rhenish lignites may be mentioned) and Quaternary deposits.

The eighth chapter deals with the faults and the water-bearing horizons, and in the ninth the conclusions at which the authors have arrived are summarized. L. L. B.

MANGANIFEROUS IRON-ORES OF LIENNE, BELGIUM.

Les Gisements ferro-manganésifères de la Lienne. *By* JOSEPH LIBERT. *Annales de la Société géologique de Belgique*, 1905, *vol. xxxii., Bulletin, pages* 144-154 *and* 3 *plates.*

About the end of the year 1886 or the beginning of 1887 active working was begun on the manganiferous deposits of the Lienne valley, a rather out-of-the-way district, then recently opened up by means of new roads and railway-lines. Three mining concessions had been granted by the Belgian Government: of these, one, the Meuville concession, covering an area of 403 acres, has never been the object of mining operations of any great importance. The Moët-Fontaine concession (covering 378 acres) was worked for some ten years, and the Bierleux-Werbomont concession (3,422 acres) was worked for nearly seventeen years. Operations have now been suspended, for economic reasons. The rocks of the district are chiefly of Cambrian age, in the Upper Salmian division of which the manganiferous ores occur among hæmatitic phyllites. West of the river, however, Lower Devonian rocks make their appearance, mantling over the Cambrian, and in one instance the ore-deposit appears to be faulted against them.

Now, a glance at the map shows that much of the Bierleux-Werbomont concession lies outside the area of Upper Salmian, the only metalliferous rock-group in the district. Indeed the mineral wealth of the region appears to be localized within a pretty restricted basin barely 2 miles long, and cut into two nearly equal halves by the Lienne river. The principal and lowest ore-bed reaches in the central portion of the field a depth of 1,300 feet or more below the valley-floor. East of the Lienne it has been worked down to a depth of 200 feet from the surface, without any trace of folding having been observed. From the available data it would be possible to estimate for this bed alone the quantity of ore as reaching several millions of tons, but when it comes to a question of actually-workable ore this estimate is subjected to a considerable discount. Be that as it may, the deposit is still of enough importance to justify a future resumption of mining operations, when the conditions of the ore-market prove more favourable and the needs of the metallurgist more insistent.

The average assays of the ore show a percentage of 38 for iron and manganese combined; the percentage of manganese alone varies from 16 to 18 and that of iron alone from 19 to 22: the manganese diminishing as the iron increases, and *vice versa*. The percentage of silica and alumina averages 30·6, and may be considered very high; there is also rather more than 3 per cent. of lime, in association with sulphur and phosphorus. In truth, the ore is a mixture of oxides and double carbonates and silicates of iron and manganese: the oxides occurring chiefly in the superficial portions of the ore-body which have suffered most alteration from atmospheric agencies, and giving a blackish tinge to the mass. Deeper down is a dark-brown ore, containing a smaller proportion of oxides. The double carbonate of iron and manganese occurs in a subcrystalline form in pinkish-white venules seaming the mass of ore, and may be properly defined, either as a manganiferous siderite or as a ferriferous diallogite. Fairly-thick venules of white quartz are also of frequent occurrence.

There is no question that the ore-body is a bedded deposit, and the roof

is very clearly marked off from the floor, the former consisting of a fine-grained thinly-foliated violet phyllite, and the latter of an alternation of coarse-grained irregularly-foliated quartz-phyllites with thin bands of manganese-ore. The principal and lowest ore-bed has an average workable thickness of 2½ feet, calculated from variations ranging from a minimum of 8 inches to a maximum of 5 feet. The lie is very irregular, the bed often pinching-out or being disturbed by faults. Moreover, the ore is of so extreme a toughness as to make its working both difficult and costly.

Some considerable distance above the principal bed occurs another one, which has been chiefly explored to the rise, on the right bank of the river, by means of a drift some 600 feet long. A little working has been done on it, and the ore proves to be of extremely variable composition. On the whole, it would probably not repay working.

Other outcrops of ore have been recorded, and are mapped by the author; but too little exploration-work has been done on them to admit of anything being said in regard to the composition of the ore.

L. L. B.

COAL-BASINS OF CARMAUX-ALBI, FRANCE.

Note sur le Bassin Houiller de Carmaux-Albi. *By* Jules Laromiguière. *Bulletin de la Société d'Histoire Naturelle de Toulouse*, 1905, *pages* 172-177 *and* 1 *map.*

Since the author first gave an account of these coal-basins in 1890, a great deal of fresh evidence has been furnished by the thirteen borings which have been put down within the past fifteen years, and by new deep-level workings. In the Sainte-Marie pit, Carmaux, four additional coal-seams (designated by the letters G, H, I and J) have been struck below seam E; and, although occasionally separated by great thicknesses of grits, conglomerates and shales, they constitute a notable addition to the richer portion of the Coal-measures. The united thickness of all the coal-seams (A—J) now proved in the Carmaux basin exceeds 100 feet.

In the Albi basin, deep-level exploration-work has confirmed the evidence obtained from the Camp-Grand bore-hole, and the four known coal-seams attain a united thickness of some 60 to 80 feet. This is without reckoning the seam of meagre coal (10 to 13 feet thick) which occurs 100 feet below the undermost of the four coal-seams just mentioned.

The Carmaux coals are of a characteristic lustrous bluish-black, while those of Albi are more of a dead black. Of volatile matter the Carmaux coals contain 25 to 26 per cent., as compared with 31 per cent. in the Albi coals; the ash from the former is less fusible than that from the latter; and, finally, the general facies of the rocks and the Coal-measure fossils are somewhat dissimilar in the two concessions. Hence the inference that, as a matter of fact, we are dealing here with two distinct coal-basins, and not with one as had been hitherto supposed.

Adducing the evidence obtained from the bore-holes, the author shows that at Rives there is a buried ridge of crystalline rocks (hornblendites) which separates the Carmaux basin from that of Albi. The existence of two basins implies, very possibly, a diminution in the actual mass of coal which was reckoned on as present, when it was thought that the supposed single basin extended continuously from the mica-schists of Vendeilles on the north, to beyond Camp Grand on the south. Allowing for this diminution, however, the Carmaux-Albi basins still take rank as among the best coal-fields in the south of France, owing to the thickness, number and excellent quality of the seams which occur in them.

L. L. B.

COAL-FIELD OF FRENCH LORRAINE.

(1) *Sur l'Allure du Bassin Houiller de Sarrebrück et de son Prolongement en Lorraine française.* *By* JULES BERGERON *and* PAUL WEISS. *Comptes-rendus hebdomadaires des Séances de l'Académie des Sciences*, 1906, *vol. cxlii., pages* 1398-1400.

The authors consider the facts which they place on record to be of considerable practical importance, since the hope is thereby fostered of finding, south of the known Coal-measure area, that part of the basin whence was derived the overthrust mass which corresponds to the Saarbrücken basin.

The Saare coal-belt extends, with a north-easterly and south-westerly strike from Nordfeld on the north to Martincourt (in the department of Meurthe-et-Moselle) on the south, and possibly beyond that. Only in the northern portion do the Coal-measures crop out at the surface, between Benbach and the Saare valley. They are conformably overlain on the north by the Lower and Middle Permians, which abut directly against the southern flank of the Hunsrück, made up of Devonian rocks. South-westward, the Coal-measures disappear beneath the Mesozoic deposits, and are only revealed by some scattered workings and more especially by bore-holes, whereof the westernmost are those of French Lorraine. On the south, the coal-belt is suddenly cut off along an imaginary line passing through Neunkirchen and Saarbrücken, an interruption generally attributed to a fault which presumably brings down the Bunter grits against the Coal-measures. The foregoing data lead to the conclusion that the Saare coal-field does not possess the character of a basin or syncline to which we are accustomed in so many coal-fields, and a recent exposure in the Frankenholz concession shows that the Saarbrücken Coal-measures rest upon an anticline of Autunian grits. This abnormal condition of things is repeated at other localities; thus, at Petite Rosselle and Merlesbach newer Coal-measures have been struck beneath older Coal-measures. Then while, in the Abaucourt boring, Stephanian or Upper Westphalian strata have been struck at great depths, the Atton and Éply borings (north of the first-named) have traversed Lower and Middle Westphalian measures, the oldest horizons being nearest the Abaucourt boring: here again there seems to be proof that the newer are underlying the older strata.

All this leads to the inference that the entire Saarbrücken basin is in reality a great overthrust mass, whereof the southern rim corresponds with the crest of a buried anticline. The sheet or mantle of Coal-measures has survived on the northern flank of the anticline, but has been eroded away from its southern flank. Certain facts are adduced in favour of this hypothesis, and the age of the overthrust is shown to be pre-Triassic. It is further shown that the overthrust mass could have only come from the south-east. Lower Carboniferous strata are known to occur on the western flank of the Vosges, and this implies the existence of a depression in that area at the dawn of the Carboniferous period. Probably, that depression existed throughout Carboniferous time, and Coal-measure sediments were deposited in it. We know that the depression (supposedly filled up with Coal-measures) continued during the Permian, the Triassic, and a part of the Jurassic age, since the respective strata occur in that area.

(2) *Sur la Flore et sur les Niveaux relatifs des Sondages Houillers de Meurthe-et-Moselle.* *By* R. ZEILLER. *Comptes-rendus hebdomadaires des Séances de l'Académie des Sciences*, 1907, *vol. cxliv., pages* 1137-1143.

In this paper, the author gives an account of his examination of no less than 10,000 plant-impressions, obtained by splitting up the cores from the

bore-holes which have been put down of late years along the presumed prolongation of the Saarbrücken coal-field. These bore-holes, nine in number, have all struck Coal-measures, have penetrated them for considerable depths, but in no case have reached older rocks. It may be remembered that five coal-seams have been proved at Pont-à-Mousson, nine at Éply, not one at Lesménils (in 2,470 feet of Coal-measures), or at Bois-Grency (in 640 feet of Coal-measures), only five seams exceeding 20 inches in thickness at Atton, four at Dombasle, one only at Jezainville and at Martincourt respectively, and four at Abaucourt.

From these many thousand specimens of plant-impressions, the author was enabled to determine 145 species of plants, some of them hitherto unknown. He gives a full list of those which are of especial interest, either from the point of view of the palæobotanist, or from that of the practical geologist eager to correlate the various horizons. A certain number of species in this list were supposed until now to be exclusively characteristic of the Saarbrücken Coal-measures; but the main importance of the author's investigation resides perhaps in the conclusions which it enables him to draw, as to the respective horizons of the measures. He shows that the beds passed through at Abaucourt undoubtedly belong to the Ottweiler group of the Stephanian; those traversed in the eight other bore-holes are assigned to various horizons of the Saarbrücken-schichten (group) of the Westphalian.

There is cumulative evidence that, as one passes from the bore-hole of Pont-à-Mousson to that of Atton, and thence to that of Éply, continuously-lower beds are met with: the uppermost beds of the second bore-hole partly corresponding with the lowermost of the first-named, and the lowermost beds of the second corresponding in part with the uppermost beds of the third bore-hole. Messrs. R. Nicklès and H. Joly had already surmised that the Coal-measures of Éply were slightly older than those of Atton and Pont-à-Mousson; which latter on the other hand would be older than those of Lesménils, and these in turn older than the Coal-measures of Dombasle. The palæobotanical evidence brought forward by Prof. Zeiller entirely confirms this supposition.

(3) *Sur les Dômes du Terrain Houiller en Lorraine française.* *By* J. Bergeron. *Comptes-rendus hebdomadaires des Séances de l'Académie des Sciences*, 1907, *vol. cxliv.*, *pages* 1185-1186.

In this paper, Prof. Bergeron lays stress on the very great plausibility of the hypothesis that the undulations or periclines, which are known to exist in the Mesozoic rocks of French Lorraine, with a general orientation from north-east to south-west, are paralleled at greater depths by similar periclines or domes in the Coal-measures; indeed, he considers that the hypothesis has now evoluted into an established fact. He has already shown that the Saarbrücken basin is really a Coal-measure fold overthrust on to an anticline of Coal-measures; and he believes that the same statement holds good of all that part of the coal-field of French Lorraine which lies north of the Nomeny fault, while the measures south of the fault belong to an anticline of the *substratum*. Hence the newer Coal-measures of Abaucourt lie much deeper down than they should, if they belonged to the same fold as the beds at Atton, Éply and Dombasle. He expects to find the tectonic peculiarities of the Saarbrücken coal-field repeated in French Lorraine. L. L. B.

UNSUCCESSFUL BORINGS FOR COAL IN PICARDY, FRANCE.

Résultats de deux Sondages profonds en Picardie. By J. GOSSELET. *Comptes-rendus hebdomadaires des Séances de l'Académie des Sciences*, 1906, *vol. cxliii., pages* 201-203.

South-west of Abbeville, the Saigneville bore-hole has just been stopped at a depth of 1,397 feet from the surface. After passing through 60 feet of recent and Quaternary deposits, 197 feet of Chalk, 285 feet of Gault and Lower Cretaceous, and 443 feet of Jurassic, it entered the Devonian grits. For comparison, the details of the Péronne bore-hole are given as follows:— Recent and Quaternary deposits, 33 feet; Chalk, 656 feet; Gault and Lower Cretaceous, 177 feet; Jurassic, 721 feet; Devonian, 52½ feet (stopped). Besides the remarkable absence of Triassic strata, there is a noticeable thinning-out of the Lias. Indeed, the Jurassic is not only incomplete in its lower members, but also in its upper, and fossils that can be determined with any certainty are scarce.

These bore-holes confirm the well-known views of the author in regard to the subterranean or deep-lying geology of Artois and Picardy. He has perseveringly maintained that below the Chalk-plain the older systems of the Dinant basin extend in the form of anticlines of Devonian grits and shales and synclines of Carboniferous Limestone. Occasionally, a patch of the Coal-measures is found in the centre of these synclines. On this hypothesis the bore-holes were put down, for it seemed just possible that in the Somme valley (which admittedly corresponds to a geological syncline) the underlying Jurassic and Palæozoic strata might reproduce the synclinal arrangement of the overlying Chalk. Here, if anywhere in Picardy, there was a chance of lighting upon a good mass of Coal-measures; possibly also on the saliferous Trias, connecting up the Triassic deposits of Lorraine with those of England; and possibly again on the pisolitic iron-ores characteristic of the Bray district.

These hopes have been disappointed, and the bore-holes prove that, if the Coal-measure basin of Lorraine does really extend far to the westward, its prolongation must lie to the south of the Bray district. L. L. B.

SHEAR-PLANES IN THE ST. ÉTIENNE COAL-FIELD, FRANCE.

Sur l'Existence de Phénomènes de Charriage antérieurs au Stéphanien dans la Région de Saint-Etienne. By P. TERMIER *and* G. FRIEDEL. *Comptes-rendus hebdomadaires des Séances de l'Académie des Sciences*, 1906, *vol. cxlii., pages* 1003-1005.

Below the Coal-measures of St. Étienne is a curious formation which has been erroneously described as a sedimentary deposit granitized in places before the deposition of the Coal-measures; but the authors' investigations now show it to be a plane of shear or crush, wherein a great variety of rocks, among which granite predominates, have been mylonized almost beyond recognition. This testifies to enormous shearing movements, etc., previous to the Stephanian age. The shear-plane is especially observable in the western portion of the coal-field on its southern and western margins, forming between the Coal-measures and the mica-schists *in situ* an almost continuous belt, extending for well nigh 17 miles from St. Étienne to Cizeron. Apart from local thickenings, it does not generally exceed 100 to 130 feet in thickness, and has much the aspect of a sedimentary group underlying the Coal-measures with a near approach to conformity. But the mica-schists upon which it rests are absolutely unconformable to the Coal-measures, and especially on the southern border their average strike makes an angle of 45 degrees with that of the

Coal-measure syncline. There is, consequently, much the same unconformity, but a tectonic one, between the mica-schists and the shear-belt: the former show signs of crushing and dragging-out in the neighbourhood of the latter. As to the basal conglomerates and red shales of the Coal-measures which overlie the shear-belt, the junction being very clearly marked, it may be noted that pebbles of all the rocks that occur in the shear-belt are found in the conglomerates, in exactly the same mylonized condition as that in which they are in that belt. Hence it may be inferred that these Coal-measures were laid down in a basin, large areas of the floor of which were covered by the relics of a shear-belt, which itself was unconformably overlying the mica-schists. Owing to erosion before and during the deposition of the Coal-measures, parts of this belt were completely swept away, thus allowing the Coal-measures to rest directly in places upon the mica-schists. Generally speaking, the basal portion of the belt, especially toughened and compacted by crush, has alone resisted erosion, and consists chiefly of mylonized granite. But, in certain depressions of the ancient pre-Stephanian surface, considerable masses of a granite survive which in nowise resembles the granites of the Central-Plateau type that are usually seen to traverse the gneisses and mica-schists of the district. It is a porphyritic alkaline granite, analogous to those of Mont Blanc and the Pelvoux. South of the coal-field, in the mountainous region where the three departments of the Loire, the Haute Loire and the Ardèche meet, the highest summits consist of a similar alkaline granite, crushed and laminated, evidently sheared off by thrust-phenomena from its original site, and dragged into its present position. Where lay the original site of the rocks that now form the shear-belt, and of these granites particularly, is a problem of which the authors have not yet found the solution. L. L. B.

IRON-ORE DERIVED FROM GLAUCONITE, ARDENNES, FRANCE.

Genèse d'un Minerai de Fer par Décomposition de la Glauconie. By L. Cayeux. *Comptes-rendus hebdomadaires des Séances de l'Académie des Sciences*, 1906, *vol. cxlii., pages* 895-897.

In the department of the Ardennes, in the district of Vouziers, and more especially at Grandpré, a Mesozoic (Aptian) iron-ore has long been worked, and has been termed an "oolitic hydrated oxide of iron." It forms loamy beds averaging 3¼ to 5 feet in thickness, sometimes attaining a maximum of 8 or 10 feet. In reality the ore-body includes several different minerals, besides cementing-material and the remains of fossils; the most abundant minerals are limonite and glauconite, and of these the author made a micrographic study. The glauconite, finely granular, is shown under the microscope to be of far less widespread occurrence than the limonite; its properties differentiate it in nowise from the glauconite of siliceous rocks, but it is perhaps most interesting when found (as here) in process of decomposition. The various appearances which it presents, according to the particular stage of decomposition which it has reached, are described, and the author shows that all the partly ferruginous minerals in the deposit correspond to grains of glauconite, more or less decomposed and altered into limonite. He holds that, although the greater number of the completely ferruginous granules exhibit not a vestige of glauconite, they are nevertheless derived from it. For one thing, the granules of limonite have precisely the same shape and volume as those of glauconite; also they have the same microscopic structure; and finally, if the limonite be placed in hot hydrochloric acid for a few minutes, it rapidly loses some of the oxide of iron to the acid (and therewith its brown coloration), assumes gradually a greenish hue, ultimately presenting the exact

appearance of glauconite-grains. Hence, it is permissible to conclude that, in this ore-deposit, the very nucleus of the ferruginous particles is of glauconitic nature, masked by the secondary limonite derived from its decomposition. The Grandpré iron-ore is unique in France in respect of its derivation. Its structure and its genesis differentiate it definitely from the pisolitic ores with which it has been hitherto confused. L. L. B.

MAGNETIC IRON-ORE OF DIÉLETTE, LOWER NORMANDY.

Structure et Origine probable du Minerai de Fer magnétique de Diélette (Manche). *By* L. Cayeux. *Comptes-rendus hebdomadaires des Séances de l'Académie des Sciences*, 1906, *vol. cxlii., pages* 716-718.

This ore occurs along the western margin of the Flamanville granitic massif, at the north-western extremity of the Cotentin peninsula, in the form of six vertical beds, intercalated among sedimentary strata which have been metamorphosed by the granite. Three of these ore-beds are seen to crop out on the beach at low tide: the others have only been proved by underground workings extending out to sea. The age of the deposit has been the subject of some controversy, but there appears to be no longer any doubt that it dates from the Lower Devonian.

As the result of a micrographic study of specimens of the ore, the author feels justified in drawing attention to the following salient facts:—(1) The undoubted existence of ferruginous bodies within the ore which have retained all the characters of the most typical oolites, with the sole exception of the concentric structure—this having been destroyed by the development of octahedral crystals of magnetite. Originally this oolitic structure must have pervaded the entire mass of the ore. (2) The irrefutable evidence that the magnetite now occupies the place of constituents which were primarily calcareous. (3) Consequently, that the ore is derived from an oolitic limestone. It may be observed that Prof. A. Bigot has discovered fossils of the nature of corals in the immediate neighbourhood of the ferruginous beds, and Dr. Cayeux identified certain nuclei of the oolitic grains under the microscope as crinoid-débris. Two hypotheses as to the actual genesis of the ore are admissible. The first presupposes that the limestone was directly metamorphosed into magnetite and hæmatite at the time of the effusion of the granite. The second relegates the replacement of the limestone by iron-ore to a period long anterior to the effusion of the granite. Pisolitic carbonates or oxides of iron, on this hypothesis, already made up the ore-beds at the time when the metamorphic influence of the granite became effective; and therefore metamorphic action was confined to a change in the state or combination of the iron in the ore-deposit. For reasons assigned, the author favours the second hypothesis. L. L. B.

AURIFEROUS STIBNITE OF MARTIGNÉ, BRITANNY.

Das Antimonitvorkommen von Martigné in der Bretagne. *By* O. Stutzer. *Zeitschrift für praktische Geologie*, 1907, *vol. xv., pages* 219-221, *with* 4 *figures in the text.*

The gold-bearing antimony-ores of Martigné-Ferchaud, in the Breton department of Ille-et-Vilaine, have found but little prominence in geological and mining literature so far. A few years ago, Baron W. von Fircks studied the surroundings and general conditions of the Semnon mine, near Martigné, and presented to the Freiberg Academy a large collection of rock-and-ore-specimens obtained by him, accompanying each specimen with a detailed

description of the occurrence and composition of the ores. The country-rocks are predominantly black slates and yellowish-brown, fine-grained, porous quartzites, through which courses a greenstone-dyke, some 33 feet in width. This dyke pitches about 75 degrees north-north-eastward, striking from west-north-west to east-south-east, and, thanks to erosion, stands out like a reef or wall at the surface. It can be traced over a distance exceeding $\frac{3}{4}$ mile, and is, in fact, the ore-carrier. A petrographical description is given of the greenstone, as seen under the microscope, and this appears generally to confirm the author's surmise that the rock is a highly-decomposed diorite or diabase.

Besides the stibnite (containing 0·0009 per cent. of gold), the Martigné ores include arsenical pyrites (with 0·0008 per cent. of gold), ordinary pyrites, limonite, and (more seldom) a little native gold. As the limonite and the native gold are evidently the products of atmospheric decomposition, the primary ores are restricted to the stibnite, arsenical pyrites and ordinary pyrites. The gangue consists chiefly of quartz and calcite, with which some brown spar is associated; vughs or druses are of frequent occurrence. The black slate at the salband is highly altered and much impregnated with ore, especially arsenical pyrites. Sericite is found both in the salband and in the gangue. It should be noted that the ores do not occur as continuous lodes within the greenstone, as is usually the case with stibnitic quartz-veins, but form a series of broken and lenticular fragmentary lodes, recalling rather the "ladder" or step-lodes of Beresovsk. These minor lodes occasionally intersect and are not seldom faulted, and their dip is predominantly at low angles: in thickness they range from 6½ feet down to a fraction of an inch. They rarely pass from the greenstone into the slates, and, when they do so, very soon nip out.

The lodes are probably the infilling of contraction-fissures in the greenstone, and from the point of view of their genesis they may be classified with the similar ore-occurrences of the central plateau of France. The industrial importance of the Martigné stibnites is much discounted, to say the least, by the considerable proportion of impurities present in the shape of arsenic.

L. L. B.

GOLD AND SILVER IN THE TRIAS OF FRENCH LORRAINE.

Sur la Présence de l'Or et de l'Argent dans le Trias de Meurthe-et-Moselle. By Francis Laur. *Comptes-rendus hebdomadaires des Séances de l'Académie des Sciences*, 1906, *vol. cxlii., pages* 1409-1412.

In the material brought up from bore-holes (put down for coal) at Raucourt and Dieulouard respectively, in the department of Meurthe-et-Moselle, the author has found certain quantities of gold and silver in association with the salt-bearing Keuper marls and Muschelkalk dolomites. Thus at Raucourt, a sample, taken from the floor of a bed of rock-salt 16½ feet thick, yielded 62 grains of gold and 92 grains of silver per ton. Far higher was the assay yielded by the siliceous Muschelkalk dolomite, since a sample showed 1¼ ounces of gold and nearly 8 ounces of silver per ton. The silver-assay corresponds with that which is usually obtained from a good argentiferous galena. Further samples from Raucourt, obtained from greater depths than the sample above cited, yielded 62 and 92 grains of gold per ton respectively, but very little silver. On the other hand, gold has not been found in the material from the Dieulouard bore-hole, but the salt-bearing red marls, at a depth of 915 feet, yield over 7½ ounces of silver per ton.

The author is expecting to secure interesting results from two pyritiferous bands which are known to occur in the Bunter Grit and the Vosges Grit of Meurthe-et-Moselle. L. L. B.

METALLIFEROUS DEPOSITS OF THE VAL DE VILLÉ, ALSACE.

Les Gîtes métallifères du Val de Villé (Alsace). By — UNGEMACH. *Bulletin de la Société française de Minéralogie*, 1906, *vol. xxix., pages* 194-282, *with* 12 *figures in the text and* 1 *map.*

Commencing with a bibliography of the subject (16 entries), the author points out that the Val de Villé, in the Alsatian Vosges, is, like the neighbouring Val de Sainte Marie, a very ancient centre of the mineral-industry. Old waste-heaps, abandoned adits and pits rediscovered in the course of the exploration-work of recent years, bear witness to its pristine activity. The fact that the ancient writers, and local traditions also, are dumb in regard to the Val de Villé, while they are so loquacious concerning the mineral wealth of Sainte Marie, is explained when one remembers that very little precious metal has been got from the former valley, while the rich finds of native silver in the latter have caused its name to re-echo "through the halls of time."

The upper portion of the Val de Villé, which is alone in question, consists of gneisses and Palæozoic shales, a belt of altered granite, some 500 to 800 feet wide, intervening between the two, and ranging from east to west. Three groups of metalliferous lodes are described: (1) the predominantly plumbiferous and cupriferous lodes of Urbeis, which crop out within or around the granitic belt; (2) the less numerous lodes of Charbes, which crop out among the shales on the southern flanks of the heights dividing the valley of that name from the Steige valley; and (3) the Triembach lodes, which occur several miles to the east of Villé in the tract of Permian or Rothliegende rocks.

Beginning with the Urbeis lodes, which yield copper, silver, lead, and more rarely zinc-ores, the author proceeds in his description from east to west, premising that all of the lodes pitch very steeply and some are absolutely perpendicular. The only mine at present worked is that of Sylvester, started in 1894: there are three veins of considerable thickness, which yield, in addition to the metalliferous ores, a vast number of magnificently-crystallized minerals, such as quartz, dolomite, calcite, fluorine, siderite, etc. Among the ores, tetrahedrite predominates, there is a little chalcopyrite, while galena, blende, marcasite, bournonite, native arsenic, etc., are of rare occurrence. The workings are conducted from four different levels joined by several shafts, and the main lode has been followed westward as far as the red Permian grit, which it does not appear to penetrate. The Donner silver-and-lead mine was worked at intervals from 1894 to 1899, the ores got from the main lode being galena, chalcopyrite, and an extremely small quantity of tetrahedrite.

The Charbes lodes have all yielded antimony-ores, occasionally zinc-ores, but never copper or lead. The Honilgoutte mine worked a series of contorted lodes of variable thickness, operations having been resumed there in 1894 to cease again somewhere about 1902. In 1900 as many as 148 workpeople were employed on that mine.

An attempt has recently been made to start once more the working of the two Triembach lodes, which crop out among the red grits by the road to Saulloch. The gangue, consisting of an altered granite, is frequently cemented by tetrahedrite, in addition to which ore and chalcopyrite, such secondary minerals as azurite (in great quantity), malachite, pyrolusite and limonite, etc., occur.

Eighty pages are devoted by the author to a detailed mineralogical and

crystallographic description of all the ores and gangue-minerals obtained from the Val de Villé, but he casts doubt on the formerly reported presence there of native gold, native silver and cobaltine. The Sylvester tetrahedrite occurs in two varieties: one rich in arsenic (6·75 per cent.) and poor in silver, and the other conversely poor in arsenic and rich in silver (5·94 per cent.): the former appears to be more distinctly an outcrop-mineral, since in depth its place is taken by the latter. The presence of as much as 1·63 per cent. of bismuth is another remarkable characteristic of the arsenical variety. The argentiferous tetrahedrite occurs in no less than seventy-one different crystalline forms, the notation of which is tabulated by the author. L. L. B.

ASPHALTIC LIMESTONES OF THE GARD, FRANCE.

Les Calcaires asphaltiques du Gard. *By* P. Nicot. *Annales des Mines*, 1906, *series* 10, *Mémoires*, *vol. x.*, *pages* 513-568, *with* 16 *figures in the text and* 3 *plates.*

The bituminous limestones of the Tertiary lacustrine basin in the department of the Gard, hitherto regarded as of no very great industrial consequence, promise, owing to recent discoveries, to rank among the most important of the kind known anywhere. They are distributed along a belt some 22 miles in length and 1¼ miles in breadth, striking approximately north 25 degrees east, and may be divided into two groups—on the south, the older and smaller workings of Servas, Cauvas, Le Puech and Les Fumades; on the north, separated by a gap of 5 miles from the southern group, the mining concession of St. Jean de Maruéjols and the vicinity. Between the two, several borings have been and are being put down, which have struck asphalt. In the Upper Infratongrian (Lower Oligocene) division, to which these bituminous limestones belong, there also occurs the lignite-series of Barjac, Avéjan and Célas, the lignites in which are worked on a small scale.

The existence of asphalt has long been known in the region, but the first Government concessions for mining it were not granted until 1844: these applied to the southern group, where the Servas workings alone remain in full activity. The concession of St. Jean de Maruéjols, granted in 1859, appears to have been extended in 1894; but, until 1902, the enormously greater extension of the deposit was hardly suspected. Moreover, the author points out that the last word has not yet been said in regard to the concessions of Cauvas and Le Puech; renewed and more systematic exploration may reveal further workable deposits thereabouts. At Les Fumades, where operations were finally suspended in 1892, the output had always been small: the stratigraphical conditions and extreme variability of the deposit were unfavourable, for one thing; and for another, the bitumen, occurring in a gritty limestone, was unsuitable for the production of compressed asphalt-powder, but had to be sorted and mixed into a paste with Trinidad asphalt and Autun tar. A detailed description is given of the Servas workings, in which the district that lies farthest south, that of Mons, is perhaps the most important. Originally covering an area of 1,638 acres, they were extended to 2,211 acres in 1862; but operations were not seriously started, in the Mons portion at all events, until about 1891. Here the asphaltic limestone, from 13 to 50 feet thick, containing three well-recognized seams of bitumen aggregating perhaps 16½ feet in total thickness, rests upon a conglomerate with Neocomian pebbles, underlain by the Neocomian *Spatangus*-limestones. Above it come clays and younger limestones, and, finally, the marls and clays with which are interbanded the *Anoplotherium*-bearing lignite-beds of Célas. Of the three seams

of bitumen, the middle one is poor and generally unworkable; but it is otherwise with the uppermost or brown seam and the lowest or black seam. The seams crop out in a hillside about 650 feet above sea-level, dip west-north-westward with a gradually diminishing steepness (from 30 degrees to *nil*), and are disturbed by strike-faults and cross-faults. A peculiar striped appearance, due to the repetition of thin streaks of bitumen interbanded with the limestone, is occasionally characteristic. The annual output of asphalt from the Servas concession averaged 600 tons between 1844 and 1890, reached a maximum of 4,600 tons from 1891 to 1895, and has decreased to 3,300 tons since 1896. In 1904 and 1905, a marked diminution of output was conditioned by momentary suspensions of mining operations, due apparently to various causes.

Turning then to the northern group of deposits, the author states that the concession of St. Jean de Maruéjols covers an area of some 702 acres; it was worked at first by inclined drifts, but for some years past all the mineral has been brought up through a shaft which it was found necessary to sink. The only seam worked has a thickness (including a central parting of unmerchantable stuff) of about 7 feet; but it is not quite clear whether this is the sole workable horizon, and fresh exploration-work, the results of which are not yet available, was started in 1906. Mining operations have been complicated by local faults and fissures, and in part arrested by water-feeders. In January, 1904, a portion of the older workings (eastern district) caved in, but as this fortunately happened on a Sunday, no one sustained injury to life or limb. The total output, from the time when operations were started there until the end of 1905, is estimated at 130,000 tons. For many years, and especially in the decade 1881-1890, the greater part of the asphalt was exported to British India; but it is now mostly taken up for London and Berlin.

A description is given of nineteen borings in the neighbourhood of St. Jean, directed to the discovery of further workable seams of bitumen; seventeen of these were put down in the years 1903 to 1905, and in five or six cases the results may be regarded as highly promising. Discussing these in detail, the author arrives at the conclusion that, in every case, the bituminous horizon which has been struck may be correlated with that already worked at St. Jean, and that its maximum thickness may approximate to 100 feet. The possible extension of the asphaltic limestone-area is limited on the east by the older rocks, and the progressive north-westerly increase in distance from the surface (or in vertical depth) of the asphaltic formation is conditioned by the dip of the beds and westward by a series of faults striking generally north 15 degrees east. Impoverishment is discernible on the north towards Fontcouverte, while southward the formation seems to disappear. How far it extends to the west is as yet unknown.

Three further bore-holes, put down in 1904-1905 between the northern and the southern groups of asphalt-workings, failed to strike any workable deposits.

Various theories of the origin of the bitumen, such as contemporaneous sedimentation, later sublimation from fumaroles, or from natural distillation of neighbouring coal-seams (Alais basin), etc., are passed in review; but the author does not commit himself definitely to any one of them.

In an appendix, he gives a short account of the bituminous oil-shales of Vagnas, in the department of the Ardèche, which occur at the same geological horizon (Cenomanian) as the lignites worked farther south at Connaux and Pont Saint-Esprit in the Gard. These oil-shales strike north-and-south, and dip 25 degrees westward. They were worked from 1859 to 1869, when mining

operations were suspended. The annual output averaged 6,000 tons of oil-shale (producing 12 per cent. of crude oil) and 1,800 tons of lignite, utilized as fuel at the shale-distillery on the spot. The overwhelming competition of American and Russian petroleum, and the expenditure which would be inevitably incurred in putting the workings into fit condition again, have checked any serious attempt to resume operations at Vagnas. L. L. B.

PHOSPHATIC DEPOSITS OF FRANCE.

Die Phosphatlagerstätten Frankreichs. By O. Tietze. *Zeitschrift für praktische Geologie*, 1907, *vol. xv.*, *pages* 117-124, *with* 2 *maps in the text.*

At one time or another some forty of the French departments have borne a more or less conspicuous share in the phosphate-output of the country; but, at the present day, phosphate-workings on any considerable scale are confined to the departments of the Aisne, Ardennes, Meuse, Oise, Pas de Calais and Somme. Elsewhere the output has either dwindled to insignificance, or has ceased altogether.

Preceding his descriptions of the principal deposits with a bibliographical list consisting of eleven entries, the author groups together those departments where the phosphates occur at approximately the same geological horizon. In the group which includes the Aisne, Nord, Oise, Pas de Calais and Somme, all the deposits that are still worked belong to the Upper Cretaceous (either Senonian or Upper Turonian, as the case may be); the Gault phosphates of Boulogne and the Cenomanian phosphates of Fauquembergues have been worked out. The pockets in which the rich phosphatic sands (containing 80 per cent. or even more of phosphate of lime) are found occasionally extend to a depth of 65 feet and more; but such pockets are nowadays seldom discovered and worked, and the phosphatic Chalk itself has assumed greater industrial importance. It is not thought that this Chalk is of deep-sea origin, but that the material was laid down in small subsiding basins, varying in longest diameter from 300 to 10,000 feet, the connexion between which (and even communication with the open sea) was frequently interrupted. A careful lithological description is given of the deposits, and a comparison with the similar deposits of Bergen, in Belgium, leads to the conclusion that the last-named represent the latest phase of a process which was at work along identically the same lines in both areas, and had begun even perhaps before the Upper Turonian in the northern departments of France.

In the group of the Meuse, Ardennes and Marne, the phosphates occur in the Lower Cretaceous green sands: these vary in thickness from 80 to 150 feet, and as their bedding is all but horizontal they extend over a considerable area. The phosphatic stratum ranges from 2 to 10 inches in thickness, being sometimes split into two thinner bands, each from 2 to 4 inches thick. The output of mineral averages from 200 to 600 tons per acre, of rounded nodules varying in size from that of a walnut to that of a man's fist. These nodules are hard, grey to greenish-brown, are sometimes scattered loosely in the sand and sometimes concreted together in masses.

Some small deposits in the Vaucluse are found in green sands of Gault age. In the neighbouring department of the Basses-Alpes, working has never got beyond the exploration-stage.

In the Ardèche, Drôme and Gard, where the phosphates are also of Gault age, the deposits of the Drôme alone yield any notable quantity of the mineral. It occurs in that department in a series of nests of extremely variable dimensions, the sifted material from which contains between 33 and 58 per cent. of tribasic phosphate of lime.

In the Yonne, a seam was at one time worked, directly overlying the *Gryphaea*-limestone at the junction between the Lower and the Middle Lias; now the phosphate is got from an underlying gravel of flints and extremely-coarse sand immediately beneath the Brienne marls, the phosphatic band averaging 8 inches in thickness. In the neighbouring department of the Côte d'Or, the *Belemnites*-limestones of the Middle Lias decompose on weathering into an iron-raddled loam, in which the phosphatic nodules are embedded; the best workable phosphates, however, in that department occur in a seam barely 6 inches thick, which belongs to the upper horizons of the Lower Lias, yielding from 120 to 160 tons of saleable mineral per acre.

In the Haute-Saône, pale phosphatic nodules (containing from 27 to 32 per cent. of phosphoric acid) were got from a band 2 to 8 inches thick, in the clays of the topmost Lower Lias; while in the department of the Cher, phosphatic nodules were worked both in the Lower Lias and in the much younger Gault. In the *causses* (limestone-plateaux) of the southern group of departments, which includes the Aveyron, Lot, Tarn and Tarn-et-Garonne, the phosphates form the infilling of dyke-like fissures extending 300 feet or more down in the Lower Oolitic limestones. The phosphate is evidently of much later age than the limestone, is generally white or grey, but occasionally iron-raddled, and contains on an average 50 per cent. of tricalcic phosphate (sometimes as much as 80 per cent.). Its association in the Aveyron with basalts and tuffs points to its eruptive origin—probably in the form of a precipitate from thermal springs. A statistical table of the output from the French phosphate-workings, covering the years 1886 to 1904 inclusive, accompanies the paper. L. L. B.

AIX-LA-CHAPELLE COAL-FIELD, GERMANY.

Die Gliederung der Aachener Steinkohlenablagerung auf Grund ihres petrographischen und palaeontologischen Verhaltens. By H. Westermann. *Verhandlungen des naturhistorischen Vereins der preussischen Rheinlande*, 1905, *vol. lxii., pages* 1-64 *and* 1 *plate.*

The records of the coal-mining industry in this area, extending as they do over a period of nine centuries, mark it out as the oldest worked colliery-district on the continent of Europe. Ancient, however, though it may be, the industry has developed so slowly that it has only attained real economic importance within the last few decades. Employing at present about 9,000 workpeople, the Aix-la-Chapelle or Aachen colliery-district yields an output of roughly 2,000,000 tons in the year. In view of the facts just recited, it is perhaps rather curious that so few geologists have concerned themselves with this coal-field, so far as published work goes, and no attempt had hitherto been made to fix the horizon of the productive Coal-measures or to investigate their possible correlation with those of neighbouring areas, more especially the Rhenish-Westphalian basin.

The surface of the Aachen coal-field, considered as a whole, slopes north-eastward, and hydrographically it forms part of the Meuse basin, the most important east-bank tributary of that river, the Roer, sweeping round the district in a vast curve, the concavity of which is directed westward. The basement-rocks are the Cambrian formations of the Venn plateau, upon which rests unconformably the great belt of Devonian strata, which make up the terraced north-western scarp of the plateau. The Devonian rocks are immediately succeeded by the Carboniferous Limestone and the Coal-measures, the latest Palæozoic formation in the district. On the west, the Coal-measures are overlain by the Senonian (Upper Cretaceous) deposits, while north-

ward and eastward they are covered by Middle Tertiary beds mantled over by wide-spread sheets of drift. These covering strata attain a thickness of some 2,000 feet or more, and are conspicuously water-bearing: the Coal-measures of the Wurm basin, however, are shut off from them by a clayey band known as the *Baggert*, which is probably the outcome of the former weathering of the anciently exposed Carboniferous surface.

The coal-field is made up of two distinct basins, one of which dips from south-west to north-east over a breadth of about 7½ miles; connecting up with this and dipping in the same direction along the line Moresnet-Aachen-Neusen, the second basin appears to pass north-westward into a third basin, that of Dutch Limburg. The two first-mentioned basins are separated by an Upper Devonian anticline, the northern limb of which exhibits a reversed, that is, a south-easterly dip of the strata. On the north-western flank of this ridge, the Carboniferous Limestone is wanting, and so the productive Coal-measures there follow hard upon the Devonian. It is inferred that a gigantic overthrust of the Devonian has taken place over the Carboniferous, and is in some way connected with the great Eifel fault which is traceable through Belgium and French Flanders into the Pas de Calais. While the north-western or Wurm basin is filled with productive Coal-measures throughout its entire extent, the Eschweiler or Inde basin (which really breaks up westward into several distinct basins) is in the valley alone of the Inde deep enough to include within itself the Upper Carboniferous. The precise extent of these basins has not yet been determined; but recent bore-holes point, at any rate, to an undoubted connexion between the Wurm coal-basin and that of Dutch Limburg. This basin has been compressed by the northward travelling Aachen overthrust, into a series of sharply-folded minor anticlines and synclines, the plication diminishing, however, in intensity towards the Dutch frontier. The Inde basin forms a single regular syncline open to the eastward, but its southern limb is overfolded. Strike-faults and cross-faults are both very numerous, but the downthrows (with some notable exceptions) are inconsiderable. The strike-faults probably date from before the deposition of the Rhenish Bunter Sandstone, while the cross-faults are of Tertiary age. Singly, the coal-seams exceed seldom 3¼ feet in thickness; but, in the Eschweiler basin their combined thickness approaches 46 feet of workable coal, in the western portion of the Wurm basin 40 feet, and in the eastern portion thereof 65 feet. In chemical properties the coal in these three areas exhibits extraordinary differences, to which may perhaps be attributed the widely-different opinions, as to the equivalence of the various seams, that have found expression among those interested in the subject.

The second part of the memoir constitutes a study of the lithological characters of the productive Coal-measures in the Aachen coal-field. They consist very largely of greyish-brown to black shales, showing between No. 4 and No. 6 seams in the Maria colliery (eastern Wurm basin) a certain amount of banding of lighter colour, which has been attributed to bleaching by upspreading vapours (?) along a belt of disturbance. One of the characteristics of these shales is the frequent occurrence of nodules and kidney-shaped masses of clayey sphærosiderite. These often form bands accompanying many of the coal-seams, but they do not contain enough iron to repay working. The sandy shales and sandstones exhibit no feature that distinguishes them from the similar strata found in other coal-fields. It suffices to remark that they are more conspicuous constituents of the Coal-measure group in the Eschweiler basin than in the Wurm basin, and they are often quarried at the outcrop for paving-stones and road-metal. The conglomerates, which appear to be of

some importance, are confined to the Eschweiler basin, where they occur at six different horizons, and the so-called main conglomerate (1,300 feet below the Traube seam) exceeds 160 feet in thickness. The coals of the Inde basin surpass all other Prussian coals in their calorific capacity; those of the western portion of the Wurm basin are anthracitic in character.

With regard to fossils, animal-remains are of small importance in this coal-field as compared with the plant-remains. The latter mostly occur in the immediate roof of the coal-seams, and, to make his collection of fossil plants, the author searched every seam that is worked. Of these plants, he furnishes an elaborate catalogue, garnished with a running commentary.

Analogies between the Aix-la-Chapelle Coal-measures and those of Westphalia are emphasized, and reasons are adduced for considering the coal-seams of the Wurm basin as of later date than those of the Eschweiler basin. Impressions of ferns, comparatively rare in the Eschweiler seams, are extremely abundant in those of the Wurm basin. The anthracitic character of the coal in the western portion of the latter basin is possibly explicable as owing to the metamorphic influence of the mighty overthrust which came from the southward. Where the measures are less sharply folded, the seams are correspondingly more bituminous. The entire thickness of the coal-bearing Carboniferous rocks of the Aix-la-Chapelle coal-field is said to exceed 6,500 feet. Many bore-holes have been put down within recent years, establishing the connexion with the Westphalian coal-field, and the only gap at present unfilled measures some 14 miles in extent. The basins of Mons, Liége and Valenciennes seem to link up with the Aix-la-Chapelle coal-field on the west.

The paper is accompanied by a bibliography of the subject and a correlation-table (wherein it is shown that the productive Coal-measures of Aix-la-Chapelle extend from below the Millstone Grit into strata which are the equivalents of the so-called "transition" Coal-measures of England). Throughout the paper the author lays very great stress on the palæobotanical evidence, and he supplies a range-diagram of the fossil plants. He concludes that deeper-lying seams than those yet known will be ultimately struck in the Eschweiler basin, and so, too, in the Wurm basin. The exhaustion of the coal-resources of the Aix-la-Chapelle district is not likely to occur for many centuries to come.

L. L. B.

RECENT BORE-HOLES AND SINKINGS IN THE RHENISH-WESTPHALIAN COAL-FIELD.

Ueber neue Aufschlüsse im Rheinisch-Westphälischen Steinkohlenbecken. By P. Krusch. *Zeitschrift der Deutschen geologischen Gesellschaft*, 1906, *vol. lviii., Protokolle, pages* 25-32.

It had long been known that the eastern boundary of the productive measures in the Rhenish-Westphalian coal-field coincides more or less with the meridian of Soest, with, of course, certain re-entrants and salients corresponding to the successive anticlines and synclines. Of late years, a series of bore-holes have been put down east and south-east of Lippborg, the results of which tend to show that the boundary of the productive Coal-measures runs approximately through Hultrop, leaving Lippborg on the west and Haus Assen on the east. Farther east and east-south-east, however, the Kessel, Krewinkel and Brockhausen bore-holes show a local eastward extension of the productive measures. This, in the author's opinion, indicates the existence of a separate basin, while at Hultrop and Haus Assen an ancient anticline, consisting of barren Carboniferous, Kulm and Devonian strata, juts out eastward into the productive measures. The Krewinkel basin is one of the

synclines of the Witten main basin, and most probably the southernmost of them.

The above-mentioned bore-holes have also indicated the possibility of coal being found beyond the boundary of the productive measures. In some cases, fragments of coal-seams destroyed by the waves of the Cretaceous sea have been washed down into the fissures which then were open in the *Stringocephalus*-limestone (Middle Devonian). In other cases, in consequence of the folding of the strata and the southward thrust of the Carboniferous surface, patches of Coal-measures have been preserved among the synclines of the older rocks. But these explanations fail to account adequately for the numerous finds of abnormally rich gas-coal east-south-east of Unna. Further bore-holes will doubtless furnish an explanation of the apparent anomaly.

In the course of a few remarks on the cross-faults which characterize the tectonics of the coal-field, the author draws attention to the extreme variations in the amount of downthrow along the strike of these faults. Thus, the Courl fault, beginning at the locality after which it is named, has there a downthrow of barely 33 feet, while 2½ miles farther to the north-west the downthrow exceeds 1,970 feet; and it diminishes again as rapidly as it increases. In this respect, a cross-fault may be compared with a cross-tear in a piece of cloth that is stretched and bears a moderate load: a curvilinear depression of that portion of the cloth is observed which is most heavily loaded (most subject to the influence of gravity).

The northward depression of the syncline of productive measures brings continuously-younger seams within reach, the farther north one goes in the coal-field; and the younger the seams are hereabouts the more bituminous they are, generally speaking. But the expectation that only the coals richest in gas, and plenty of them, would be found in the northern portion of the Rhenish-Westphalian basin has been falsified. This is mostly due to the intervention of main anticlines between the synclines and of local synclines within the same; and an exception of this kind is illustrated by recent sinkings at the Auguste-Viktoria colliery, north of Recklingshausen, where at horizons which usually yield gas-coals, the meagre coals (upper division) were struck, vaulted up into an anticline.

A series of bore-holes, put down on the left bank of the river Rhine, west of Mörs, have struck productive Coal-measures immediately after passing through 660 feet of Tertiary deposits. The Coal-measures have a very low dip, rarely exceeding 5 degrees, and the seams belong to higher horizons than had been looked for. On the left bank of the river Rhine, the seams (smaller in number than on the right bank) belong more predominantly to the meagre-coal group: these meagre coals are thicker and purer than on the right bank; in fact, as a whole, their lie and their quality recall in many respects the seams of that district of South Wales which yields the smokeless steam-coal. L. L. B.

APPENDICES.

I.—NOTES OF PAPERS ON THE WORKING OF MINES, METALLURGY, ETC., FROM THE TRANSACTIONS OF COLONIAL AND FOREIGN SOCIETIES AND COLONIAL AND FOREIGN PUBLICATIONS.

BROWN-COAL DEPOSITS OF UPPER LAUSITZ, SILESIA.

Die Braunkohlenformation des Hügellandes der preussischen Oberlausitz. By KURT PRIEMEL. *Zeitschrift für das Berg-, Hütten- und Salinen-wesen im preussischen Staate*, 1907, *vol. lv., Abhandlungen, pages* 1-72, *with* 13 *figures in the text and* 6 *plates.*

The brown-coal deposits of this district constitute the western portion of the so-called Sub-Sudetic brown-coal formation, that is, the lignite-bearing Tertiaries which are banked up on the northern margin of the Sudetic range. To the south and to the west of them lie near at hand the brown-coal deposits of the neighbouring kingdom of Saxony; and, through their connexion with the brown coals of Brandenburg and Posen, they may be regarded as a part of the great series of such deposits which extends over East and West Prussia, Pomerania, Mecklenburg, Silesia, etc., known generally as "the North-east German brown-coal formation." According to Prof. H. Credner's view, this is of Miocene age, while he assigns to the Lower Oligocene the so-called Sub-Hercynic brown-coal series (Harz region, Halle, Leipzig, etc.).

The hilly portion or highland country of the Upper Lausitz, with which Dr. Priemel's memoir more especially deals, is built up of flat ridges of ancient granites, gneisses and slates, traversed by eruptive basalts which seem occasionally to follow a certain alignment. In the hollows among these older hills lie considerable masses of the Tertiary formation (the brown coal-bearing beds included) capped by Quaternary deposits, in their turn forming flat-topped hills, which lend additional variety to the landscape, rising to altitudes of 1,000 feet or more above sea-level. The Neisse, the principal river of Upper Lausitz, cuts through the granite at Görlitz in a deep gorge of erosion; but, as it flows northward, its meanders gradually become more frequent, while the hills become fewer and lower, merging finally into the barren sandy heath-country characteristic of the North German plain.

Although it is possible to distinguish several brown-coal basins wherein the coal-bearing Tertiary deposits have attained a considerable thickness, it would be a mistake to speak of "Tertiary basins," as it is the coal-seams alone that are discontinuous or cut off one from the other, while the sands and clays of the formation almost invariably spread from one basin to the next, linking the whole series together.

A description is given of the rocks which underlie the brown-coal formation: namely, the granites and gneisses; the Silurian grauwackés and quartz-schists; the Permian limestones and quartzless porphyries; the red sandstones, etc., of the Trias; the Upper Cretaceous sandstones and mottled clays. As to the eruptive columnar basalts, there is no doubt that, with some rare exceptions, they also are older than the brown-coal formation. There is,

however, proof that eruptions were still continuing even during the deposition of that formation.

The author then proceeds to describe in succession (1) the Görlitz-Ostritz brown-coal basin; (2) the finds of coal west and north-west of Görlitz, which do not seem to be of much importance; (3) the Hermsdorf-Schönbrunn coal-belt; (4) the Troitschendorf coal-basin; (5) the brown-coal deposits in the neighbourhood of Lauban and Lichtenau-Geibsdorf; (6) those of the Marklissa district (unimportant); (7) the brown-coals of the western extension of the Löwenberg basin; and (8) those of the Muskau district. He adds to these, for the sake of comparison, a description of the Zittau basin, across the border in Saxony. Details are given of a great number of bore-holes, and the fifth chapter of the memoir is devoted to a consideration of the pressures and thrusting which the Tertiaries of the region underwent during the Glacial period.

The sixth chapter is taken up by a stratigraphical summary; and in the eighth chapter the final results of the author's minute and laborious investigations are set forth, somewhat as follows: The brown-coal formation of Upper Lausitz includes on an average one to two seams, which may, however, be split by partings occasionally into four or more seams. The thickness of the seams ranges from 20 inches to 52½ feet, leaving out of account thinner and industrially unimportant seams. Given an average thickness of Tertiary deposits, brown-coal is almost invariably found, if not always at workable depths; and at the very least such substitutes as bituminous marls or clays with venules of coal occur. There are some cases of wash-out. The beds of the brown-coal formation, consisting as they do of clays, sands, gravels and coal-seams, are of extraordinarily variable character, and any attempt to tabulate (even locally) a normal succession of the strata within that formation is all but impracticable. On the whole, its age may be set down as Lower Miocene, and the seams appear to have originated from the drifting-together of plant-remains in lakes and flood-areas.

The Lichtenau district is a typical scene of active mining operations, the Glückauf mine there being the most important of any in Upper Lausitz. Shafts are sunk some 120 to 150 feet down to the main seam, which attains a maximum thickness of 40 feet in the middle of the basin, gradually thinning out towards the edges. The yearly output of brown-coal averages 106 million cubic feet (tonnage not stated), the number of workpeople employed in and about the mine being 400. The coal yields only 4 per cent. of ash, and its heating-power is equivalent to 2,500 calories. Two briquette-factories are attached to the mine.

The brown-coal worked in the Louisa mine at Nieder-Schönbrunn is of such ligneous character that, even when moist, it cannot be compressed into briquette-fuel. The average yearly output amounts to 688,000 bushels (tonnage not stated), the number of workpeople oscillating between 40 and 50. A pumping-installation above bank drains the mine of 220 gallons of water per minute. The main or upper seam attains a maximum thickness of 13 feet, and is separated by 4 to 5 feet of marl from the lower seam, which varies in thickness from 20 to 40 inches. The various shafts in use go down to depths of 130 and 160 feet.

In the Troitschendorf district, the Joseph Hermann mine employs 30 workpeople, and yields an annual output of some 12,000 tons. Two shafts are sunk, and the pumping-engines drain the mine of 286 gallons of water a minute. Speaking generally, the Troitschendorf seam increases in thickness eastward and south-eastward from 6½ feet to 20; the coal is tough and compact, yields 5¾ per cent. of ash, and contains no less than 53·06 per cent. of water.

In the northernmost bay of the Görlitz-Ostritz basin, the Friedrich Anna mine at Moys, where two shafts are sunk to a depth of 154 feet, produces annually 64,000 tons of coal; 30 per cent. of this, classified as dust, is used up in the briquette-factory attached to the mine. The pumping-installation below bank is capable of dealing with over 1,100 gallons of water per minute; but the average flow does not, as a matter of fact, exceed 550 gallons per minute. The mine employs 120 workpeople. The main seam averages 29½ feet in thickness, gradually decreasing to 6½ feet towards the rim of the basin, the seam then rising very steeply and suddenly nipping out.

L. L. B.

POSIDONIA BECHERI IN UPPER SILESIAN COAL-MEASURES.

Das Auftreten von Posidonia Becheri in der oberschlesischen Steinkohlenformation. *By* R. Michael. *Zeitschrift der Deutschen geologischen Gesellschaft*, 1905, *vol. lvii., Protokolle, pages* 226-229.

Prof. Fritz Frech having announced that *Posidonia Becheri* has now been proved to range up into the productive Coal-measures, and that consequently the discovery of that fossil in the process of boring for coal should not discourage the prospector, the author sets himself to controvert this conclusion, and to show that it is at all events inapplicable to the Upper Silesian coal-field. There, a series of strata, 13,000 feet in thickness, intervenes between the undoubted Kulm slates containing *Posidonia Becheri* and the beds which contain *Posidonia constricta* (or *membranacea*). These are still to be regarded as two distinct species, although Prof. Frech maintains that in reality the finely-ribbed *Posidonia constricta* is specifically indistinguishable from *Posidonia Becheri*.

The true *Posidonia Becheri* is confined in Upper Silesia to the barren Lower Carboniferous, and the author warns all whom it may concern against the useless expenditure of time and money in boring for coal in areas which have been accurately mapped as Kulm. Moreover, he believes that the same statement, in regard to the restriction of the range of *Posidonia Becheri*, will be found to hold good in Westphalia also. L. L. B.

ASPHALT-DEPOSIT AT METTENHEIM, HESSE.

Ueber ein Asphalt-Vorkommen bei Mettenheim in Rheinhessen. *By* A. Steuer. *Notizblatt des Vereins für Erdkunde und der Grossherzoglichen Geologischen Landesanstalt zu Darmstadt, series* 4, 1905, *part xxvi., pages* 35-48.

The village of Mettenheim lies on the west side of the Rhine valley, about midway between Worms and Oppenheim, at the base of a vineclad elevation. This elevation represents the eastern abutment of the Tertiary deposits along the great Rhenish fault, although they are mostly concealed from view by a great mass of drift and loess. In digging for wells in the neighbourhood, bituminous limestones have been met with, of compact structure, yellow and blue coloration, and a brittle and splintery character, interbedded among blue marls like unto the *Cyrena*-marls. The author had a bore-hole put down at a favourable spot, but, owing to the inadequacy of the available apparatus, he did not reach a greater depth than 115 feet. However, he ascertained that the bituminous limestones, struck only a few feet below the surface, are equivalents of the *Corbicula*-beds (Lower Miocene). The asphalt actually crops out in the form of a layer, 4 inches thick, in the northern bank of a hollow lane near by, and in the lane itself. Down to a depth of 65 feet or so, the asphalt recurs in the form of bands several inches thick, among the marls as well as

in the limestones; below that depth no more of it is found. Three specimens from various depths have been analysed and compared with Trinidad asphalt. They seem to be of generally higher specific gravity than the Trinidad mineral, and while that only melts at 275° Fahr. (135° Cent.) they melt at 212° Fahr. In chemical composition they bear fairly close comparison with the Trinidad asphalt, the proportion of carbon ranging roughly from 50 to 54, of sulphur from 6 to 6½, of mineral impurities from 17½ to 25½. All four asphalts were alike in regard to their relative solubility and insolubility in different liquids, such as alcohol, benzol, turpentine, etc.

The greatest enrichment of the asphalt-deposit is not so much in the limestones as in the marls, especially between the depths of 53 and 60 feet. A premature announcement in the newspapers of the results of the bore-hole caused the descent of an avalanche of enquiries upon the local municipal authorities, some speculators wishing to bore eventually for petroleum (which in the Mettenheim district would be a quite hopeless undertaking, judging from the available geological data).

It does not seem very likely that even the asphalt will repay working, on anything like a commercial scale. At all events, an old mining concession, granted under the laws promulgated during the Napoleonic régime, and covering the entire commune of Mettenheim, has still legal force, and it includes the asphalt-deposit. L. L. B.

KAOLIN-DEPOSITS OF HALLE-AN-DER-SAALE, SAXONY.

Die Entstehung der Kaolinerden der Gegend von Halle a. S. *By* Ewald Wüst. *Zeitschrift für praktische Geologie*, 1907, *vol. xv., pages* 19-23, *with* 7 *figures in the text.*

The kaolin-earths of the Halle district are, for the most part, derived from quartz-porphyries; but how they are so derived has long been a matter of controversy. According to one hypothesis, the quartz-porphyries (mantled over though they were by Tertiary deposits, drift, and alluvia in succession) were and are being decomposed by atmospheric agencies; the process, which began as far back as the Upper Oligocene time, has continued down to our own day, and that very mantle of later deposits has prevented the products of decomposition of the porphyries from being swept away to other localities. According to another hypothesis, the kaolinization of the quartz-porphyries is the outcome of post-volcanic pneumatolytic and hydrothermal phenomena immediately connected with the eruption of the porphyries, and consequently dating back to the Lower Rothliegende period. The author's own researches have led him to propound a theory essentially different from either of those just outlined. He attaches some importance to the fact that there is a certain amount of regularity about the distribution of the Halle kaolin-deposits; in every case they are associated with the older Tertiary land-surface, upon which the continental sediments of the Lower Oligocene brown-coal formation were laid down. Wherever the quartz-porphyries immediately underlie these Lower Oligocene deposits they are kaolinized, and the author regards the Halle kaolin-earths, as a whole, as forming a portion of an extensive crust of weathering, in part broken and disjointed by later denudation. But many other pre-Tertiary formations, besides the porphyries, constituted the above mentioned ancient land-surface; and, wherever they occur in contact with the Lower Oligocene plane of deposition, they exhibit signs of intense chemical decomposition:—thus the Lower and Upper Rothliegende arkoses, the Upper Rothliegende porphyry-breccias and porphyry-conglomerates are kaolinized, the red sandstones both of the Rothliegende and the Bunter are bleached, as also the

red marls of the same formations, the Muschelkalk limestones are in part crumbled away to calcareous sands, and so forth.

The crust of weathering below the older Tertiary land-surface is here defined as belonging to the group of the grey earths, which are essentially characterized by kaolinization of the felspars, bleaching of the ferruginous constituents, and in damp climates are the outcome of the action of humic acid on the components of the surface-rocks. This crust was already in existence when the Lower Oligocene brown-coal deposition was beginning; and, no doubt, under conditions which were so favourable to the activity of humic acid as those of the brown-coal epoch were, the crust must have further increased in thickness. The point which the author perhaps most of all emphasizes, in sketching the origin of the Halle kaolin-earths, is the influence of humic acid; but he expressly disclaims any desire to put this forward as the principal factor in the genesis of all kaolin-earths. He agrees nevertheless with Dr. E. Ramann that, probably, most of the kaolin-deposits of Central Europe were formed in Tertiary times by humic-acid weathering. The practical interest of the paper, if the author's views prove unassailable, lies therein that kaolin-earth deposits may be looked for wherever porphyries form the bed-rock of the ancient Tertiary land-surface; now, by piecing together evidence from various sources, it will prove quite possible to map out this ancient surface, and this is an undertaking to which the author will shortly address himself. L. L. B.

NICKELIFEROUS MAGNETIC PYRITES OF THE BLACK FOREST, BADEN.

Die Nickelmagnetkieslagerstätten im Bezirk St. Blasien im südlichen Schwarzwald. By E. Weinschenk. *Zeitschrift für praktische Geologie*, 1907, *vol. xv., pages* 73-86 *and* 2 *plates.*

In the autumn of 1906, the author made a detailed study of the deposits of nickeliferous magnetic pyrites, situated in the district of St. Blasius, in the southern portion of the Black Forest, being partly moved thereto by the fact that, although repeatedly mentioned by many writers, these deposits had not so far been made the object of really careful investigations on the spot.

He begins with suggesting the erasure, from the list of acknowledged mineral species, of horbachite (so-called by Prof. Knop from the farmstead of Horbach, near Wittenschwand) declaring it to be synonymous with true nickeliferous magnetic pyrites. At the same time, he admits that chemical analyses of specimens of the ore, taken from the Horbach mine, show it to be a fairly constant mixture of iron and sulphide of nickel, corresponding either to the formula Fe_3NiS or to the formula Fe_4NiS; and that consequently the name "horbachite" may ultimately hold good. This ore is constantly associated with varying quantities of iron-pyrites and chalcopyrite, the former of which plays a very subordinate part in the opencast workings at Horbach (and would appear to be of small industrial value, as it contains at most a minute proportion of cobalt). The chalcopyrite, on the other hand, assumes occasionally some importance; and the general average ratio of nickel to copper in the Horbach ores ranges between 2:1 and 3:1. The infinitesimal proportion of platinum which usually characterizes the metalliferous ores in other districts of the Black Forest is here conspicuous by its absence.

Stress is laid on the general resemblance between the Scandinavian and Canadian nickel-ore deposits and those here described, despite admittedly marked differences in individual details. All nickeliferous magneto-pyritic ores, properly so called, lie within the direct sphere of influence of granitic

masses, occurring perhaps especially along the contact-zone of a granite and a more basic eruptive; but they are not limited to one or to the other of these rocks, although as a rule they are incomparably more fully developed in the basic eruptive. In its fresh condition identified as an olivineless, frequently quartziferous norite (but metamorphosed successively into olivine-gabbro, picrite, and even hornblende or bronzite-peridotite) this forms the typical matrix of the nickel-ores in Norway as in Canada, in Piedmont as in the Southern Black Forest. It would seem evident that the granite is the younger rock, which welled up after the solidification of the original ore-carrier, and often enwrapped masses of the more basic rock.

Once the drift-deposits of the Rhine-valley are left behind, the country thence as far as St. Blasius is seen to consist of a complex of granites and gneisses among which is repeatedly intercalated a variety of so-called "crystalline schists," the literature of the subject according special mention to serpentine; among these are intruded a great number of eruptives, in the form of dykes and sills, the quartz-porphyries between St. Blasius and Höhenschwand furnishing conspicuous examples thereof. A few patches of Bunter Sandstone and of drift overlie in places the crystalline rocks. The narrow valleys and gorges afford innumerable fine exposures, and quarrying operations are active, the rocks being of use, some as building-stones and others for road-metal. The most important metalliferous mines, for the greater part worked opencast, are that of Horbach (already mentioned) and that in the Scheuerloch at Todtmoos.

The granites frequently tend to become markedly porphyritic, while on the other hand they pass by every conceivable gradation into the gneisses. The dyke-rocks are described in some detail, and the author then proceeds to show that the so-called "serpentinized gneisses" (regarded by some observers as good indicators of the nickel-ore), never were gneisses, nor are they by any means trustworthy indicators. Despite the extensive exposures afforded by the opencast workings of Horbach and Todtmoos, geological investigation is considerably hampered by the fissured and crushed condition of the rocks; moreover, the weathering of the pyrites has set up much superficial decomposition, and efflorescences of pale-green salts of nickel and bluish-green salts of copper everywhere help to mask the original appearance of the rock. Nevertheless, it is ascertainable that the richest ore (consisting mainly of sulphides) is concentrated in a compact dark rock, seamed in places by veins of white to pinkish aplite which broaden out into almost horizontal sheets. At Todtmoos, where the ores assume the form of lodes, the despised iron-pyrites occurs in considerable quantity; while at Horbach such ore as occurs in masses consists chiefly of feebly-lustrous nickeliferous magnetic pyrites, but the more frequent occurrence there is in the form of an abundant impregnation of the rock, the chief associates of the nickel-ore being magnetic pyrites, chalcopyrite, and but little ordinary pyrites. Not much of all this is very visible in the hand-specimens, but their high specific gravity, the results of the chemical analyses, and finally microscopic examination, confirm the presence of far greater percentages of ore than are superficially discernible.

Although both these ore-deposits (Horbach and Todtmoos) belong to zones which have undergone the most intense contact-metamorphism, it is still possible to identify the unaltered basic eruptives. Thus, the norite of Todtmoos (described in detail) agrees in every particular with the most typical norites of Sudbury. From Horbach comes a very fresh rock, but of far more basic character, being a true hornblende-gabbro, the felspar of which has been determined as labradorite. But perhaps the most noteworthy rock of all is

that which predominates in the Horbach mine: macroscopically, it appears to resemble the blue ground of the South African diamond-fields; its high specific gravity and its high percentage of nickel (4 to 5) contrast with its unpromising appearance in the hand-specimen, so far as metalliferous ores are concerned.

The question of the genesis of the ore-deposits is discussed at some length, and reasons are adduced for holding that the basic eruptive rocks were themselves originally free from nickeliferous and cupriferous pyrites; these ores were brought in after the intense metamorphism of the rocks, largely attributable to the influence of the granitic magma, had taken place. In a word, these and similar nickeliferous deposits are not the outcome of magmatic differentiation, but are properly defined as contact-deposits in the genesis of which a molten granitic-aplitic complex played a prominent part. At the same time, the deposition of nickel more especially (as contrasted with the absence of nickel in many other ore-deposits of similar origin) may be traced to electrolytic action originating in the basic eruptive rocks. L. L. B.

STANNIFEROUS DEPOSITS OF THE FICHTELGEBIRGE, BAVARIA.

Das Vorkommen von Zinnstein im Fichtelgebirge und dessen Gewinnung im Mittelalter. *By* ALBERT SCHMIDT. *Zeitschrift für das Berg-, Hütten- und Salinen-wesen im preussischen Staate*, 1906, *vol. liv., Abhandlungen, pages* 377-382, *with* 1 *figure in the text and* 1 *plate.*

In the district with which the author deals, the axis of the Thuringian Forest cuts across the axis of the Erzgebirge, and the mutual shock of these mountainous massifs has promoted by its metamorphic effects the formation of rare minerals. In the main, the Fichtelgebirge is built up of granite, and attains a maximum altitude of 3,454 feet. It was the scene in remote historical times and in the Middle Ages of an active mineral-industry, chiefly directed to the washeries for stream-tin. At one locality only was cassiterite actually mined in its quartz-matrix by means of shafts and adits, and that was in the immediate neighbourhood of Weissenstadt. The geological conditions of the occurrence of the ore are identical with those observed in other more famous tin-mining districts. Its presence is undoubtedly traceable to pneumatolytic phenomena connected with the extrusion of the granites: fluorspar, lithia-mica, tourmaline, topaz, apatite, beryl, associated in magnificent druses, and the sporadic appearance of greisen, complete a catalogue that is familiar to us from other localities. The tinstone itself occurs only at the contact with the granite, where the inevitable fissure facilitated the full development of fumarolic action. At Schönlind, near Weissenstadt, six stanniferous lodes have been identified, striking from south-south-west to north-north-east through a gneiss very similar to mica-schist, and pinching out in a hard stanniferous diorite-schist. Tin-mining was pursued here for more than three centuries from 1402 onwards, and the old adits and heapsteads were still to be seen about 20 years ago, but now all has been levelled. At the Seehaus, the highest point (3,122 feet) where human habitations exist in the Fichtelgebirge, cassiterite was at one time mined in a quartz-vein, but the workings are now overgrown with forest and whortleberry-bushes. Other abandoned workings are described, and it is evident that the lamentable Thirty Years' War wrought dire havoc among the mines of this district.

The author hints at a possibility of re-opening the Schönlind mines, the old plans of which are still available, and even the long-abandoned Seehaus workings; but he is more than doubtful as to the chance of stream-tin washeries in that district ever proving remunerative again. L. L. B.

HOLZAPPEL METALLIFEROUS BELT, HESSE-NASSAU.

Die südwestliche Fortsetzung des Holzappeler Gangzuges zwischen der Lahn und der Mosel. By G. Einecke. *Bericht der Senckenbergischen Naturforschenden Gesellschaft in Frankfurt am Main*, 1906, *part ii., Wissenschaftliche Mittheilungen, pages* 65-103, *with* 2 *maps and* 2 *plates.*

The earlier geologists, chief among them Messrs. — Bauer and F. Wenkenbach, had classified the lead, silver, zinc, and copper-ore deposits, which are dispersed through part of Hesse-Nassau between the Rhine and the Lahn, into an eastern and western group of lodes respectively. In the former was included the Holzappel metalliferous belt, traced as far back as 1841 over a length of 30 miles or more. It was thought that the extension of this belt in a south-westerly direction must be looked for towards Wellmich, Werlau, and Peterswalde. This idea must now, however, be abandoned, and the ore-belt is shown to strike through the neighbourhood of Oberwies, Schweighausen, and Dachsenhausen, to the Rhine valley at Bornhofen, passing thence by Ehr, Liesenfeld, and Sevenich, near Corweiler, where it joins up directly with a group of lodes that extends to Zell on the Moselle. Taken as a whole, this great belt has a west-north-westerly and east-south-easterly strike, with a dip in its central portion of 40 degrees, which steepens to 60 degrees towards both extremities. The rocks in which it occurs are a mighty complex of Lower Devonian (Coblentzian) quartzites, greywackés, greywacké-slates, and shales, broken through in places by intrusive diabases, porphyries, and basalts, and at some few localities unconformably overlain by strata of later age. A network of fissures some 130 to 160 feet in breadth extends through these Devonian rocks for a distance of 41 miles, from Holzappel on the Lahn to Zell on the Moselle; the fissures are infilled with quartz and metalliferous ores, with a marked enrichment (especially of galena) in the north-eastern portion. Proceeding south-westward, however, the observer will note the diminution of galena and zinc-blende, while copper-ores increase in quantity, and there is simultaneously a proportionate increase of the quartz, occasionally to such an extent as to involve the disappearance of all metalliferous ores whatsoever. On approaching the Moselle, zinc-blende is seen to increase again in quantity. It is noted that many of the cross-faults of this fissure-system coincide in direction with the tributary valleys of the Lahn and the Moselle, while in the Rhine valley there is no sign of any faulting of the ore-belt. Parallel with the lodes and occasionally uniting with them, as at the Gute Hoffnung mine at Werlau, certain white dykes course through the rocks; while a series of white dykes of later age cut across both the older dykes and the metalliferous lodes.

Detailed descriptions are given of the main lode (average thickness 3¼ feet) as it is seen to occur in the Holzappel and Leopoldine Louise mines at Dörnberg, and again in the Gute Hoffnung mine at Werlau, and the reasons for controverting the earlier views as to the correlation of the Holzappel ore-belt with Mr. Wenkenbach's eastern group are marshalled at great length.

L. L. B.

PYRITES-DEPOSITS OF THE WESTERN ERZGEBIRGE, SAXONY.

Zur Kenntniss der Kieslagerstätten zwischen Klingenthal und Graslitz im westlichen Erzgebirge. By Otto Mann. *Abhandlungen der Naturwissenschaftlichen Gesellschaft Isis in Dresden*, 1905, *pages* 86-99.

Within recent years, mining operations, long suspended, have been restarted at the ancient copper-ore workings on the Eibenberg, between Klin-

genthal and Graslitz. The industry in that region can be traced back for at least six hundred years; the volume and number of the old mine-heaps bear witness to its former extent and activity, while considerable accumulations of slag point to the association of the metallurgist with the miner.

Those who are now conducting operations have penetrated much deeper down than the old miners, and the information thereby obtained has furnished matter for the various quickly succeeding memoirs of Messrs. C. Gäbert, R. Beck, and B. Baumgärtel. The views of these authors in regard to the origin of the deposits are discussed by Dr. Mann, who has studied the rocks both in the new deep-level workings and above bank. The ore-deposit lies at the base of the tongue of Graslitz slates (which penetrates for about 3 miles eastward into the Eibenstock massif); it does not belong to the actual contact-zone, but lies rather within the group of normal slates or Lower Phyllites. These are of a pale-green colour with a silky lustre, and contain much quartz in the form of nodules; chlorite is one of the common constituents of the rock, and a small quantity of pyrites is almost invariably present. The strike is approximately north and south, and the dip about 30 degrees westward. The particular ore-body to which the name Segen Gottes (God's blessing) has been applied, is, like the other ore-bands which have been proved hereabouts, intercalated on the whole conformably among the slates. Its lower portion consists predominantly of a succession of layers (about 20 inches thick) of ordinary pyrites and magnetic pyrites: in the richest part of the deposit the partings of slate disappear entirely, but in the poorer part the slate and the ore may be found to alternate in layers of extreme tenuity. In places, the ore assumes rather the form of lenticles and pockets, which, however, still show a general conformity with the country-rock. The occasional brecciated structure of the magnetic pyrites is not very easily accounted for; that the magnetic pyrites was deposited later than the ordinary pyrites may be inferred from the fact that broken crystals of the latter are often found enveloped by the former.

The upper portion of the Segen Gottes deposit differs from the lower, both in its mineralogical composition and in its habit or facies as a whole. While in the lower part the general conformity extends down to the minutest details, the intercalation even of infinitesimally fine ore-bands among the schists being perfectly regular, and similarly that of tenuous schist-bands among thick bands of ore, unconformity is often a marked feature of the upper part. Here the ores not infrequently occur in the form of stringers, which traverse the schists in different directions, and are plicated and contorted into an inextricable complex, although sometimes they present the appearance of being conformably intercalated among the schists. Magnetic pyrites, iron-pyrites, copper-pyrites, zinc-blende, and quartz are all jumbled together, one or other of these minerals being absent in places. The predominant ore in these stringers, however, is copper-pyrites, the one mineral of the deposit that repays working. The occurrence of magnetic pyrites in this connexion is peculiarly interesting, as it is properly not a vein-mineral, but is generally found in metamorphic deposits. The chronological sequence of the minerals here cannot be determined; indeed, it rather looks as if they were the outcome of contemporaneous or practically simultaneous deposition.

The entire deposit, from top to bottom, yields unmistakable evidence of the action of dynamic agencies, not unrelated, perhaps, to the phenomena of mountain-building. With regard to its genesis, the author enters into an elaborate discussion of the theories generally held as to the formation and alteration of pyrites-deposits. Geologists are generally averse to concede

the possibility of a sedimentary origin for such deposits, but he points out that data which tell in favour of this hypothesis are available; and he draws attention to the part played in the deposition of pyrites by organic matter, and even by micro-organisms. In conclusion, he assumes that the lower portion of the deposit described by him is of sedimentary origin, and that the upper portion is of epigenetic origin; and that probably both regional metamorphism and contact-metamorphism are the factors responsible for the presence of magnetic pyrites. The stringers represent the results of the leaching-out of the original deposit, and there has been a selective enrichment of the copper-ore in them, owing perhaps to the "smelting" effect of the intrusive granite.

Dr. Baumgärtel publishes some criticisms of this paper in the pages immediately following it, but they do not appear to affect seriously the main facts and conclusions cited in the foregoing abstract. L. L. B.

TUNGSTEN-ORE DEPOSITS IN SAXONY.

Über ein kürzlich aufgeschlossenes Wolframerzgangfeld und einige andere neue Aufschlüsse in sächsischen Wolframerzgruben. By R. Beck. *Zeitschrift für praktische Geologie*, 1907, *vol. xv., pages* 37-45, *with* 9 *figures in the text.*

Despite the active demand which has grown up of late years for these ores, it was not until the summer of 1906 that exploration-work was seriously inaugurated in the neighbourhood of Tirpersdorf. Yet, as long ago as 1890, the officers of the Saxon Geological Survey mapped the deposits and described them in detail, the first discovery having been made in 1889 by Dr. M. Schröder, an investigator well known for his special acquaintance with the granite-massifs of the Western Erzgebirge and the Voigtland and their contact-aureoles. The metalliferous lodes in question occur in the immediate vicinity of Tirpersdorf, near Ölsnitz in the Voigtland; and their outcrops fall mostly within the outer, but partly within the inner, contact-aureole of the Bergen and Lauterbach granite-massif, which starts at the Hohe Reuth, somewhere about a mile and a quarter north-north-east of Tirpersdorf. Cambrian slates, with sills of highly amphibolized diabase, abut here against the granite, the metamorphic effect of which upon the slates is to convert them into andalusite-mica rocks, cordierite-bearing cherts, and various forms of schist, etc. Wolframite, a little molybdenite, and a pearly-grey mica occur, in association with druses and long acicular crystals of tourmaline, impregnating veins of a greasy white quartz which traverse the tourmalinized schists north, east, and south of Tirpersdorf. The wolframite, in view of the high percentage of iron and the small percentage of manganese that it contains, must be classed among the tungstates of iron: it is found in broad, tabular, imperfect crystals measuring up to 4 inches in thickness, or in compact masses. Occasionally the wolframite is seen to be in process of decomposition into brown iron-ore, in which case films and aggregates of yellowish wolfram-ochre are observed to clothe the walls of neighbouring fissures. Tourmalinization of the schists, the final stage of the contact-metamorphism, is seen to have proceeded from the lodes, as well as probably from the granite itself.

When the author visited the Gertrud mine in November, 1906, he found that three parallel lodes had been opened up, and two more (which have been since then explored) probably belong to the same group. What is provisionally termed the "main lode" strikes north 5 to 10 degrees west, dips east-north-eastward at 35 to 40 degrees, and averages 13 inches in thickness. About 30 or 33 feet below this is another lode with the same dip, and measuring some 10 inches in thickness; the remaining parallel lodes lie a little farther

away to the eastward. All the outcrops occur in the left flank of a lateral valley of the Elster river-basin, and will be easily worked by means of an adit; while an abandoned mill at the foot of the slope will be the natural scene of operations for the treatment of the ores. A mass of rock-débris from 3¼ to 5 feet thick masks the actual outcrops in every case.

With this occurrence the author contrasts the mineralogical associations of the cupriferous mines of Sadisdorf, near Altenberg, where no tourmaline is found, while on the other hand wolframite appears in company with lithia-mica, fluorspar, and apatite. Even the Sadisdorf mines are only just beginning to take rank as tungsten-producers, yielding in 1905 rather over a ton and a quarter of wolframite and 10½ tons of molybdenite. All other tungsten-ore occurrences in Saxony are or have been worked in conjunction with cassiterite-deposits, and so cannot be compared in any way with the Tirpersdorf ores, which, taking everything into consideration, constitute a so far unique type of lode, with perhaps the single exception of the Germania I. lode at Deertrail (Washington), U.S.A. The author has received and examined specimens from Deertrail, which he cannot differentiate from the Tirpersdorf mineral.

Turning then to the wolfram-tinstone lodes of Zinnwald, which averaged an annual output of 37 tons of tungsten-ore during the decade and a half from 1890 to 1905, the author states that a new mine was recently opened up close to the Bohemian frontier, and in 1905 was already yielding over 12 tons of wolframite. This mine is a delight to geologists, because it furnishes capital sections of the contact-zone between the Zinnwald granite and the Teplitz quartz-porphyry which envelops that rock on all sides. Of these a detailed description is given, noting by the way that the Hansa lode, the most productive as yet struck in the mine, is about 18 inches thick and is accompanied by a parallel stringer of mediocre or little importance. Although the dip seems to steepen greatly when the lode leaves the granite and cuts through the quartz-porphyry, the lode actually thickens in places in the latter rock, attaining a maximum therein of 3¼ feet—as far as it has been yet followed. The Wilhelm lode, on the other hand, higher up the watershed, shows at first no essential change in thickness or mineralogical composition, but gradually thins away and becomes impoverished in the quartz-porphyry, until (at a distance of 65 feet from the granite-boundary) it has dwindled to 3 inches in thickness and no longer repays working. These wolframite-lodes (so-called "seams"), clearly distinguishable from the narrow, steeply dipping stanniferous veins, are probably of slightly later origin than the latter in some cases, and practically contemporaneous in others. L. L. B.

GRAPHITE-DEPOSITS IN THE PIEDMONTESE ALPS.

La Grafite nelle Alpi piemontesi. By Vittorio Novarese. *Atti della Reale Accademia delle Scienze di Torino*, 1905, *vol. xl.*, *pages* 241-254.

The announcement of the recent discovery of graphitic lenticles in the Pietre Verdi of the Val di Lanzo has induced the author to collect together into one paper the observations on similar occurrences, recorded by his colleagues and himself in the course of the geological survey of the Piedmontese Alps.

Taking for granted that Alpine graphites are in many localities, if not in all, the outcome of the metamorphism of deposits of fossil fuel, the presence of graphite in a formation may prove to be of fundamental importance in regard to the determination of the age of the rocks, as well as a considerable factor in the solution of the stratigraphical and tectonic problems that may

arise in connexion with that determination. Recent research has demonstrated that the double-zone classification of Gastaldi, which served as a good working hypothesis in its generation, is at variance with the actual facts, being in fact too refreshingly simple to square with them. Rocks, formerly lumped together all into one system, are now recognized to belong to very different ages, despite lithological and other resemblances.

The graphite of the Ligurian division of the Alps is the result of a local metamorphism of anthracites of Carboniferous age. It may be noted, by the way, that in this area the graphite-outcrops are of small importance, in comparison with the extent and frequency of the anthracite-outcrops. The converse holds good in the Cottian Alps, to which the author now passes, omitting the Maritime Alps, where no authentically recorded occurrence of graphite is known. In the Cottian Alps, the Alpine graphites assume perhaps their greatest development, occurring at two widely separated horizons—the lower being most certainly of Carboniferous age, and the upper belonging to the Mesozoic formation of the calc-schists. The most important graphitic belt, in regard both to extent and to industrial value, lies within the Dora-Varnita gneissose ellipsoid. It was first described by the author in 1898,* and the observations made since then have, on the whole, confirmed that description. In 1902-1903, the existence of seams of anthracite was proved in the graphite-belt; but, as already hinted, it would appear that in these Cottian Alps anthracite forms the exception and graphite the rule. It has also been ascertained that the best deposits of the latter mineral occur in the immediate proximity of the dioritic masses of the lower valley of the Chisone, with which are associated spotted chiastolite-schists, etc. This leads to the inference that the action of contact-metamorphism has in this region played some part in the transformation of coal-seams into graphite, the more so that the few known outcrops of anthracite are the farthest away from the eruptive rocks.

In several localities, but more especially in the little valley of Pramollo, a phenomenon has been observed identical with that already noted in the graphite-mine of Isola Grande in the Ligurian Alps. The graphite-bed sends out ramifications and apophyses which cut clearly across the country-rock; and the graphite which forms these apophyses, etc., is very much purer than the mineral of the bed itself. This may be explained as due, either to injection, conditioned by pressure, of the most bituminous, and consequently most plastic portion of the original coal-seam, previous to the action of contact-metamorphism; or to the immediate effects of that metamorphism, in which case the graphite, as the result of the distillation of the coal-seam, might have been deposited as a sublimate in fissures and other available cavities in the country-rock. The hypothesis of Dr. Weinschenk, that certain deposits of talc are derived by pseudomorphosis from graphite, appears to the author improbable in the highest degree.

The graphite-deposits occurring among the Cottian Alps in Gastaldi's "zone of the Pietre Verdi" (mostly associated with the Mesozoic calc-schists) are of small industrial value. In the Graian and Pennine Alps, on the other hand, graphites crop out at five different horizons at least. The belt of country which the author defines as that of Sesia-Val di Lanzo consists predominantly of gneisses and mica-schists; these, contrary to the opinion generally received at one time, have nothing whatever to do with the Pietre Verdi and the Mesozoic calc-schists. The presence of intrusive rocks of later date than the great foldings is characteristic, but the age of the Sesia-Val di Lanzo belt can only be determined by approximation: it is certainly as old

* *Trans. Inst. M. E.*, 1899, vol. xvi., page 520.

as the Carboniferous, and possibly very much older. In the lower Val-di-Lanzo the plumbago-deposits belong to the type of graphitic mica-schists and graphite-schists; in Val d'Orco the deposits belong to a more unusual type: the graphite occurs in the form of nodules and flakes, dispersed amid a rock carrying big garnets in a white groundmass (or matrix) irresolvable by the microscope. It seems reasonable to assume that the mode of origin of these two different types can have hardly been the same for both.

The graphite-lenticles, etc., of the northern limb of the Valsavaranche anticline are of undoubted Carboniferous age, while graphite-deposits of equally undoubted Mesozoic age have been met with elsewhere in the Graian and Pennine Alps.

A brief description is given of occurrences of graphite-bearing rocks, both north-west and south-east of the dioritic belt of Ivrea; among them are certain graphitiferous kinzigites, in regard to which the author recalls the existence of the ancient Olivadi mine in Calabria, where kinzigites have been worked for the graphite-nodules which they contained. L. L. B.

AZURITE-DEPOSIT OF THE CASTELLO DI BONVEI, SARDINIA.

Il Giacimento di Azzurrite del Castello di Bonvei, presso Mara, con alcune Osservazioni sulla Formazione dei Carbonati di Rame naturali. *By* F. Millosevich. *Atti della Reale Accademia dei Lincei, series* 5, 1906, *vol. xv., Rendiconti, pages* 732-740.

The metalliferous deposits which occur among the trachytic rocks of north-western Sardinia, over an area that about covers the administrative district of Alghero, have been the object of some little prospecting-work, hitherto unattended with any very brilliant results. The scientific interest which they present is, however, considerable; and so the author seized the first opportunity that presented itself of examining the cupriferous deposit worked by the Mayor of Pozzomaggiore, at the Castello di Bonvei, in the commune of Mara, about half-way between Pozzomaggiore and Monteleone, that is, about the centre of the metalliferous area as above defined.

The hills which make up the greater part of this district consist mainly of Miocene limestones capped in places by the remnants of basaltic flows of later date. In places in the valley-bottoms erosion has laid bare the andesitic and trachytic rocks (Lamarmora's "ancient trachytes") of pre-Miocene age. On the north-eastern flank of the hill, which is crowned by the ruins of the old castle of Bonvei, several bands of azurite or chessylite, intermingled with a little malachite, are exposed in a limonitic clay, overlying a pinkish andesitic trachyte. The last-named rock is much altered, contains numerous felspathic inclusions (chiefly plagioclase) and the ferro-magnesian constituents are represented by abundant biotite; it bears no trace itself of metalliferous ores, whereas the steep grey rock above (which more nearly approaches the true trachytes, and upon which the old castle stands) is mineralized. This grey trachyte has a groundmass rich in felspar-microliths and chalcedonic spherulites, with some felspathic inclusions and large and abundant crystals of hornblende; between it and the azurite-bearing clay intervenes a great siliceous dyke, a sort of compact quartzite that seems to have invaded the trachyte.

Although the workings, so far, are of the most superficial description, a considerable quantity of azurite has already been got: the bands of the ore average 8 inches in thickness, and one of them attains a thickness of 20 inches. In the upper layers, clay predominates, and the ore occurs in isolated spheroids

of varying size, sometimes conjoined, or in masses of pisolitic appearance; lower down, where the proportion of clay is smaller, the ore is grouped together in little seams or in masses presenting a compact mammillated structure. The lowermost bands, in contact with the underlying pink andesitic trachyte, have a barytic instead of an argillaceous gangue. The malachite which is associated with the azurite was evidently deposited at the same time as the latter. Few specimens of chalcopyrite and bornite have come to light thus far, but deeper workings will most probably reveal the presence of these sulphidic ores in greater quantity, especially in the quartzose dyke above mentioned.

This Sardinian occurrence recalls the Schemnitz and Kramnitz deposits of Hungary; still more vividly, in the character of the minerals and other circumstances (geological age excepted), does it recall the deposits of Chessy and Sain-Bel near Lyons. The Bonvei ore-deposit, all things considered, is probably older than the Miocene limestones which abut against the trachytic Castle-rock.

It is well known that soluble salts of copper, originating from deep-seated sulphidic ores, can react with carbonates (generally with that of lime) to form the basic carbonates of copper. And this is unquestionably the manner in which most of such ore-deposits have been formed. But, why should malachite be of so much more frequent occurrence than azurite, even admitting that the former is a more stable mineral species than the latter? And why, as at Chessy and Castello di Bonvei, should the usual preponderance be reversed, azurite predominating so enormously over malachite in both these localities? The author set himself to answer these questions by means of experiments directed to the artificial preparation of azurite. He found that this formed at temperatures lying between 167° and 185° Fahr., by means of the reaction of cupric chloride with an excess of sodium-carbonate in the presence of carbonic-acid gas, and he concludes that this excess of carbonate and the presence of the gas are probably two of the necessary conditions for the formation of azurite in nature. The propinquity of an argillaceous stratum and the intermingling of clay with the ore in course of formation, slacken the reaction, and probably help to prevent the further evolution of azurite into malachite. L. L. B.

TUNGSTEN-ORES IN THE CAGLIARI DISTRICT, SARDINIA.

Giacimento di Minerali di Tungsteno a Genna Gurèu ai Limiti fra Nurri ed Orroli (Cagliari). *By* Domenico Lovisato. *Atti della Reale Accademia dei Lincei, series 5, 1907, vol. xvi., Rendiconti, pages* 632-638.

The occurrence of tungstates of iron and manganese in Sardinia was first made known in April, 1898, when the author announced the results of his examination of a few small fragments obtained from the metalliferous mine of S'Ortu Beciu. In the course of two subsequent visits to the locality, he ascertained that the amount of wolfram-ore present must be very small, as on one occasion he found none at all, and on another only a minute quantity (a very few grammes) of it. Since then tungsten-minerals have been discovered at the Su-Suergiu and Genna-Gurèu antimony-mines. At the last-named mine especially does scheelite occur in such abundance and of such excellent quality, as to induce the author to journey thither in May, 1904, and February, 1905, for the express purpose of investigating the occurrence on the spot. For many years past antimony-ores have been worked here, but no one had suspected the importance which the deposit might assume, particularly in depth, in regard to its tungsten-ores. The rocks of the immediate

vicinity are schists, in part argillaceous, in part micaceous, but rarely talcose, ridged up into a series of mammillated hillocks, the appearance of which recalls in some cases volcanic cones, seamed by innumerable veins of quartz and much disturbed by porphyroidal intrusions. In these schists (which are most probably of pre-Palæozoic age) and in the underlying rocks are found first of all the antimony-ores and then, as one goes deeper down, the tungsten-ores.

The scheelite of Genna Gurèu occurs in crystalline masses, and shows in habit much resemblance with the scheelite of Zinnwald and Schlackenwald in Bohemia. In colour it ranges between pink and white, being rarely yellowish or greyish; but in every case the streak is white. It forms in the schists veins of varying thickness, which are said to attain a maximum of 8 inches; though perhaps these veins might more correctly be described as long drawn-out lenticles. In hardness the mineral is below 5 in Mohs's scale, and its specific gravity probably lies between 5·9 and 6·1. Chemical analysis shows it to consist of 80·42 per cent. of tungstic oxide (TuO_3), 19·6 of lime, and 0·07 of iron sesquioxide (Fe_2O_3), with very slight traces of silica and magnesia. Molybdenum, present in all other scheelites hitherto known, is curiously absent from the Genna-Gurèu mineral.

On his second visit, the author paid especial attention to the inferior quality of scheelite, which occurs below the schists in a more granular and compact form, commingled with meymacite, stibnite, and other sulphides of antimony and lead, amid quartzose rock. This deeper-lying scheelite is externally decomposed into a yellowish-green, occasionally orange-brown, meymacite (its ordinary decomposition-product, so named from Meymac, in the Corrèze, France, where it was found in association with native bismuth, etc.). There is no bismuth associated with the Genna-Gurèu mineral, and the meymacite itself differs in some respects from the French variety. The author's analysis, indeed, would seem to show that, according to the degree of hydration, there are various passage-minerals between the original scheelite and the ultimate meymacite. L. L. B.

METALLIFEROUS DEPOSITS OF NORTH-EASTERN SICILY.

Die geologischen und tektonischen Verhältnisse der Erzlagerstätten Nordost-Siziliens. *By* B. Lotti. *Zeitschrift für praktische Geologie*, 1907, *vol. xv.*, *pages* 62-66, *with a map in the text.*

The geological structure of the Peloritan mountains in the province of Messina is briefly described as follows: the lowest rocks seen consist of grey or bluish-grey mica and chlorite-schists with knots of quartz, with which are associated towards the top of the series, but in quite a subordinate fashion, sericitic gneisses. Locally, the schists are metamorphosed into biotite-hornblendites, actinolite-chloritites, epidotic and garnet-bearing hornblendites, etc. Among these schists are intercalated, at various levels, but increasingly towards the summit of the series, a few bands of white and grey crystalline limestones, passing upwards into the middle group which consists predominantly of thickly-bedded crystalline limestone. This latter, however, shrinks in places into a few thin layers or into an isolated lenticle. The uppermost group consists chiefly of coarse-grained gneiss and sericite-gneiss with intercalations of mica-schist, more especially biotite-schist, traversed over large areas by innumerable veins of pegmatite. In the lowermost schists such veins are extremely rare, and in the limestones they are, with one exception, entirely absent. The age of the formations here described is a matter for conjecture; if reliance is placed on the analogies which they offer with similar Alpine formations, they may date back to the Archæan or the Silurian, or

they may date no farther back than the Mesozoic Era. Direct evidence, such as would be furnished by a fossil flora or fauna, is not available.

Ore-deposits have been known, and in part worked, in this region since the eighteenth century; but this knowledge has been, in the main, restricted to the lower spurs of the mountains. Recently another series of ore-deposits has been discovered higher up, in the very heart of the range, although no actual mining work has been carried out on them as yet. The newly discovered ores occur all but exclusively, like the earlier-known deposits, in the lowermost schist-formation, and they may be grouped as follows: (1) bedded iron-ores (magnetites) passing into ferruginous zinc-blende; (2) reef-like or lenticular quartz-masses with chalcopyritic magnetic pyrite; (3) lead-and-zinc-bearing quartz-veins; and (4) quartz-veins with fahlores and chalcopyrite.

The principal outcrops of the first formation occur on the Tyrrhenian side of the range, on the northern flanks of Monte Maulio and Monte Maorno. With the ores are invariably associated the bands of crystalline limestone, already mentioned as being interbedded with the lower schists at various horizons. The metalliferous deposits assume the form of lenticles of varying thickness—from an inch or so to 6½ feet, consisting of compact or fine-grained magnetite, with finely-disseminated particles of zinc-blende and pyrite. The limestone at the junction is occasionally impregnated with these ores. Chemical analyses show that there is every grade of passage, from a magnetite with more than 60 per cent. of metallic iron, into a true ferruginous zinc-blende. The ore-deposits have been involved in the movements of plication of the country-rock and, like it, are greatly dislocated.

A little below the middle limestones, at about the same stratigraphical horizon as the magnetites, there occur amid the schists lenticular mases of vein-quartz with ordinary pyrite and magnetic pyrite: in the central portion of the lenticles the last-mentioned ore is usually pure and compact, but towards the periphery some chalcopyrite makes its appearance. The immediately surrounding country-rock is invariably metamorphosed into epidotic and garnet-bearing biotite-hornblendites with superficial iron-staining. It is possible that these lenticles are but the dispersed fragments of what were originally fissure-veins. Analysis of a specimen of magnetic pyrite showed it to contain 47·2 per cent. of iron; 32·5 of sulphur; 0·7 of copper; 0·2 of nickel and cobalt; and 15·1 of insoluble residue.

The lead and zinc-ores, which are the predominant feature of the earlier-known deposits, occur in the area dealt with in two great quartz-reefs, one of which crops out at the base of Monte Tossazza, near the chalets of Issala, while the other is seen in the little valley of Sterra, at the foot of the Pizzo della Croce. The Issala reef is of variable thickness, expanding in places to 30 or 40 feet. The country-rock consists of gneisses and mica-schists, which are traversed by muscovitic and chloritic granite-dykes and associated with ferruginous limestones. This reef can be followed along the outcrop for 330 yards or more: the ores, consisting of galena intermingled with black zinc-blende, take the form of venules or small aggregates disseminated in the quartz. The very thickness of the reef protected it in some respect from the shattering and dislocation which overtook deposits of lesser importance; even so, it shows at the junction with the country-rock certain irregularities that bear unmistakable witness to dynamic processes connected with orogenic phenomena. The other quartz-reef contains only galena in compact masses: so far as it has been opened up, it averages 10 feet in thickness, and seems to be very highly mineralized. It is, however, so mantled over by rock-débris and vegetation, that close study of the outcrop and a reliable estimate of the industrial value of the occurrence are at present impracticable.

A little way downhill from the Issala chalets, a small quartz-vein, with venules of fahlore and disseminated particles of chalcopyrite and black zinc-blende, is seen to traverse the lower hornblendic and garnetiferous schists. The vein is 2 feet 7½ inches thick, and is extensively mineralized; it tends rather to assume a lenticular shape, and is probably a fragment of a pre-existing vein which was shattered in the course of mountain-building processes.

That groups (3) and (4) are genetically vein-deposits appears to admit of no doubt; but, in regard to groups (1) and (2)—the magnetite and magnetic pyrite—the author tentatively suggests that the first was formed by "chemical molecular substitution of limestone-bands," and that the second represents probably the shattered remnants of fissure-veins forced into, and folded in with, the beds of country-rock. He has no hesitation in asserting the genetic relationship between the ore-deposits and the granite-intrusions, the more superficial apophyses of which are traceable in the granite-dykes that have already been mentioned. It may be noted, by the way, that pyrite is of frequent occurrence in these dykes. Reasoning by analogy with similar geological and lithological conditions in Sardinia, the author holds that the ore-deposits probably date from the period that followed on the great Hercynian plication, that is, some time between the Upper Carboniferous and the Permian. But while Sardinia thereafter remained an immovable fault-block or *horst*, unaffected down to the present time by the great orogenic movements and the consequent dislocations, both Sicily and Calabria were sorely visited by the dynamic phenomena that repeatedly resulted from the great Alpine and Apennine plications in the Tertiary Period. In Sicily, the crushing, shattering, and dislocation undergone by the granite-dykes and the ore-deposits recall vividly the similar vicissitudes to which the pre-Tertiary ore-deposits have been subjected in the Apuan Alps, where indeed the miner encounters at every step great difficulties in following up the strike of the rocks.

L. L. B.

BLENDE- AND GALENA-DEPOSITS OF TRAAG, NORWAY.

Über die Erzgänge zu Traag in Bamle, Norwegen. By J. H. L. Vogt. *Zeitschrift für praktische Geologie*, 1907, *vol. xv., pages* 210-216, *with 5 figures in the text.*

On the western side of the Skien fjord, in the immediate vicinity of the south-western extremity of the area geologically defined as the Christiania region, a belt of metalliferous lodes strikes sensibly parallel with the junction between the fundamental rocks and the Silurian over a length of some 15½ miles, while its breadth ranges between 3 and 3¾ miles. The district is hilly, but the maximum altitudes do not exceed 660 feet above sea-level. The fundamental rocks hereabouts consist predominantly of a somewhat compressed red granite with occasional patches of hornblendite, and, in some few localities, bands of quartzite identified as belonging to the uppermost stage (the Kragerö quartzite-stage) of the Archæan system of Southern Norway. The author's researches among these rocks were limited to the neighbourhood of Traag, where mining operations have been started, north and south of which town the ore-belt extends to beyond Vaddres and Tangvall respectively. Many of the lodes were traced uninterruptedly for 2, and some for 2½ miles: by far the larger number strike parallel one with the other, and they pitch as a rule steeply (80 to 85 degrees westward), an easterly dip being exceptional. The more important lodes average 3¼ to 6½ feet in thickness, but some few attain thicknesses of 15, 20, and even 25 feet. They may be shortly defined as quartz-

breccia veins, quartz being the predominant infilling-material. Calcspar is of exceptional occurrence, and fluorspar is conspicuous by its absence. Brecciated fragments of the country-rock, often highly mylonized and chemically decomposed, occur abundantly in these lodes. The principal ores are zinc-blende containing but a small proportion of iron, and galena containing an average percentage of 0·05 of silver. In some of the lodes, a little chalcopyrite and pyrites occur, while spathose iron-ore, occasionally altered into brown hæmatite, is found in others. Mining operations were begun a few years ago, and the greatest depth from the surface so far reached ranges from 200 to 230 feet. The innumerable smaller lodes are poorly mineralized. Of later age than these quartz-breccia veins, are the diabase-dykes which coincide with them in strike and dip, and alternately course along the footwall or the hanging-wall, or along the central strip of the lodes, bifurcating sometimes within them.

It seems plain that the order of events was as follows: fissures were torn in the rocks; these fissures were afterwards infilled with quartz and metalliferous ores; at a later date the metalliferous lodes, coinciding with planes of weakness in the earth's crust, were torn open again, and diabase in the molten condition was intruded along them. At Styggedalen, the exceptional occurrence of a later, very drusy, barytes-vein alongside the metalliferous quartz-breccia vein is noted.

As the broader lodes offer less resistance to the atmospheric agents of erosion than the tough, hard, country-rock, the metalliferous outcrops generally occur along small valleys or swampy tracts, as implied in the very composition of the place-name Styggedalen (ugly dale).

The author marshals at some length the evidence for regarding the above-described lodes as fault-fissures, arising in the course of the great sagging movement which took place during Devonian time, and was perhaps continued into the Carboniferous age, in the Christiania region. This region constitutes a vast *graben* or fosse, some 143 miles long and in places 50 miles broad, within which the sunken tract of the earth's crust is broken into innumerable fault-blocks thrust one against the other. The work of denudation since these phenomena took place has been so great, that it is reckoned that the present surface at Traag lies many thousands of feet—or, say, a couple of miles below the surface as it was when the lodes were formed. It seems probable that these lodes, even now extending to a depth of 5,000 feet or so, must have originally had a depth which ran into miles. L. L. B.

GELLIVAARA AND KIIRUNAVAARA IRON-ORES, NORTHERN SWEDEN.

(1) *Die Eisenerzlagerstätten bei Kiruna.* *By* O. Stutzer. *Zeitschrift für praktische Geologie*, 1906, *vol. xiv., pages* 65-71, *with* 1 *figure in the text.*

At the end of August, 1905, the author paid a visit to the deposits of the Kiirunavaara, Luossavaara, and Tuollavaara, which, probably for brevity's sake, he describes as the deposits of Kiruna, after the settlement of that name north of the Arctic circle. The annual output of iron-ore already exceeds 1,500,000 tons, and most of the workings are opencast, affording splendid and ever-varying exposures for geological study. The Kiirunavaara is a ridge extending from north to south for about 2½ miles, and rising to an altitude of 2,460 feet above sea-level; its eastern face is abrupt, while the western slopes gently downward, and its northern end abuts on the lakelet of Luossajärvi. Across the lake, the Luossavaara (altitude 2,391 feet) is the evident

continuation of the ridge just described; mining operations have not yet been begun on this northerly extension. On the other hand, an hour's journey by road east of Kiruna, a deposit analogous to that of the Kiirunavaara is worked in the small hill known as Tuollavaara.

The crest of the Kiirunavaara and the summit of its northern extension across the lake consist of pure magnetite, with some apatite, while the flanks of both ridges and those of the small hill just mentioned are made up of porphyry. The plain from which these eminences arise is partly swamp and partly a waste of drift-gravel, but syenite has been proved on the west, and the so-called Hauki Slates with conglomerates and overlying quartzites have been proved on the east.

The author proceeds to give a brief petrographical description of the rocks, going from west to east; wherefore he begins with the augite-syenite, the finer-grained varieties of which occur at the margin of the porphyry. Prof. L. de Launay's statement that a passage is observable from the former rock into the latter is here recalled. Bore-holes having proved a definite steep eastward dip of the iron-ore (varying between 50 and 60 degrees), the western porphyry is termed the footwall-rock and the eastern the hanging-wall; the former, of a greyish-green colour, is generally more basic than the latter variety, which is usually red and contains a certain amount of quartz. Viewed from a distance, the junction between the magnetite and the footwall-porphyry seems generally to be well-defined, but, on a nearer approach, a passage-belt from pure porphyry into pure magnetite is perceived, and occasionally clean-cut dykes of magnetite are seen to have penetrated the igneous rock. The magnetite belongs to two generations: (1) properly bounded crystals which lie within the felspars, and are the probable result of primary differentiation; and (2) magnetite of "secondary immigration," which has partly flowed round the felspars, and has partly invaded them along the cleavage-cracks. At the junction of the porphyry and the ore, a belt of impregnation is of most frequent occurrence; comparable, in some cases perhaps, in structure with a net, the meshes of which would be formed by magnetite and the interstices filled up with porphyry; comparable in other cases with a breccia, whereof the groundmass is a compact magnetite, amid which are dispersed angular, highly-uralitized fragments of porphyry. The ultimate member of the series is a rock which in hand-specimens appears to consist solely of black magnetite and green hornblende; such specimens are to be found in the Tuollavaara deposit, but always at the junction with the country-rock, not in the midst of the ore-body. The ore-body of the Kiirunavaara attains a maximum thickness of 830 feet, but on the whole the thickness varies between 112 and 500 feet. Prof. J. H. L. Vogt has estimated that the amount of ore present in that ridge, and under the Luossajärvi lake down to a depth of 1,000 feet, and then in its continuation in the Luossavaara ridge, attains a combined total of 750,000,000 tons, whereof only 100,000,000 tons are to be got by opencast working. The ore is tough and hard, consists mainly of pure magnetite, more or less intermingled with apatite, and contains from 67 to 71 per cent. of metallic iron. There is no ferruginous gossan, as all the weathered stuff was swept clean off the surface by the glaciers which ground their way over the country in prehistoric times.

Tuollavaara was mantled over by ground-moraine, which has now been removed, and reveals a rocky eminence worn quite smooth and polished by ice-action. A great dark mass of magnetite, magnificently striated, crops out amidst the porphyry: the direction of the striae in this neighbourhood is from south-west to north-east, showing that the glaciers came down from

the Kebne Kaisse (altitude 7,000 feet), the highest mountain in Sweden. The annual output of ore from Tuollavaara alone is estimated to reach 70,000 tons. Besides the ubiquitous apatite and the asbestiform hornblende of the impregnation-zone, other associates of the ore are calcite, rarely quartz, still more rarely talc, brownspar (chalybite), iron-pyrites, and titanite. The results of a microscopic examination of the acidic hanging-wall porphyry are detailed, and they show it to be of later age than the ore-body and the basic footwall-porphyry. The description of the rocks is followed by a very careful discussion of the various theories put forward in regard to the genesis of these ore-deposits, and the author assigns at length his reasons for concluding that the main mass of the ore is of epigenetic-magmatic origin ("a magmatic differentiate which made its way upward"); while the ore of the impregnation-belt may be compared with that of a contact-deposit. It is shown how the facts fail to fit in with any other explanation.

(2) *Die Eisenerzlagerstätte Gellivare in Nordschweden.* *By* O. STUTZER. *Zeitschrift für praktische Geologie*, 1906, *vol. xiv.*, *pages* 137-140, *with* 2 *figures in the text.*

This paper opens with a bibliographical list consisting of 21 entries. The author, in the course of his journey through Scandinavia in 1905, visited the celebrated Gellivaara mines among others, and considers that there is no need to lay stress on their universally-admitted importance; but he points out that controversy still rages in regard to the genesis of the deposits. Nothing can end this controversy, short of convincing evidence that the country-rock is of eruptive origin; meanwhile the author thinks it advisable to set forth the data upon which he bases his own conclusions.

The ore, consisting, like that of Kiirunavaara, of magnetite and apatite, but differing therefrom in its granular crumbly texture, is as yet mostly worked opencast in a small ridge or range of hills rising to an altitude of 2,025 feet above sea-level. The deposit furnishes undoubted evidence of recrystallization under pressure, and so does the country-rock, consisting chiefly of gneisses. Of these, and of the so-called granite and pegmatite, rocks rich in quartz which traverse the ore-body, a detailed description is given. Both the ore-deposit and the country-rock have slaty cleavage, and the general strike is east and west, while the dip is to the south at a very high angle, approaching indeed the vertical. Inclined as he was at first to regard the Gellivaara deposit as of sedimentary origin, a closer view induced the author to change his opinion, and the analogy with Kiirunavaara points to a common origin for both deposits. The lie of the deposits, the mineralogical character of the ores, and the nature of the country-rock, all tell in favour of the epigenetic theory. This may be considered as already proved in the case of Kiirunavaara, where the ore is a magmatic dyke, the outcome of deep-seated magmatic differentiation. And the Gellivaara deposit is a metamorphosed example of this, associated with very marked lateral impregnation.

(3) *Die Eisenerzlagerstätten bei Kiruna.* *By* O. STUTZER. *Zeitschrift für praktische Geologie*, 1906, *vol. xiv.*, *pages* 140-142, *with* 1 *figure in the text.*

The author describes at some length a hand-specimen of brick-red porphyry, encircled successively by pale apatite, a ring of magnetite, and lastly, pale apatite again, from Luossavaara. He argues that it furnishes additional proof of the epigenetic (magmatic) origin of the deposits, and that it also shows that the apatite and magnetite must have simultaneously made their way upward from their deep-seated birth-place. L. L. B.

GRAPHITE-DEPOSITS IN LAPLAND.

Anorganische Graphitvorkommen in Lappland. *By* O. Stutzer. *Centralblatt für Mineralogie, Geologie und Paläontologie*, 1907, *pages* 433-435.

During a recent sojourn in Lapland, the author was furnished with information as to certain graphite-deposits which are being explored in the district whereof Svappavara is the centre, and specimens of the mineral were presented to him by the concessionaires. Already in 1899, Dr. F. V. Svenonius, of the Swedish Geological Survey, had mentioned graphite-deposits of no mean importance as occurring to the west, north-west, and east of Vittangi (a locality situated 17½ miles east of Svappavara). In one of these deposits (Palapöviö, east of Vittangi), 300 feet or so long and 16½ to 33 feet wide; the country-rock is a granulite traversed by pegmatite-dykes, and the graphite contains impurities in the shape of rock-inclusions. At Maltosrova, a deposit of excellent graphite, more than 300 feet in length and 15 feet in breadth, is found; it probably strikes across to the Äjärova hill, on the newly constructed main road, 7 miles west of Vittangi. This hill is built up chiefly of granite and syenite-granulite, and at its eastern base crops out a coarse-grained gabbro impregnated with magnetite: the graphite is said to occur at the contact with this gabbro. The mineral is traceable for 2½ miles farther north-eastward, as far indeed as Jälketkurkkio on the Torne-Elf; and it is from that locality that the specimens examined by the author were obtained: they include, besides pure graphite, gabbro (wherein the pyroxene is completely altered into hornblende) strongly impregnated with graphite. In place of the largely-decomposed porphyritic felspars, the microscope reveals a mosaic of small secondarily-formed plagioclases amid which the graphite forms a cloudy mesh: it is evidently of later formation than the secondary felspars, and with it is associated a good deal of magnetite. The occurrence of this graphite among and within igneous rocks is conclusive evidence of its inorganic (presumably pneumatolytic?) origin.

It is as yet too early to say whether the above-mentioned deposits are likely to assume industrial importance, but it may be well to bear in mind that several other graphite-deposits are known to exist in Lapland—at Skatamark, at Tallberget on the Öre-Elf, and at other localities. L. L. B.

AURIFEROUS DEPOSITS OF FINNISH LAPLAND.

On the Occurrence of Gold in Finnish Lapland. *By* Curt Fircks. *Bulletin de la Commission géologique de Finlande*, 1906, *vol. iii., No.* 17, *pages* 1-35, *with* 15 *figures in the text, a frontispiece and a map.*

This paper embodies the results of investigations made by the author in the course of a three months' sojourn in Lapland; but, for the sake probably of completeness, he gives an account of the placer-deposits based on the work of Mr. E. Sarlin, while his own studies were directed more particularly to the gold-bearing veins. During the period of 30 years which elapsed between their first active working in 1870 and 1900, the alluvia along the rivers Ivalojoki, Sotajoki, Palsinoja, Tolosjoki and Luttajoki, with their respective tributaries, yielded an average output of 460 ounces of gold. The auriferous district is, on the whole, mountainous, while the rivers are fringed by bogs, occasionally of considerable extent. The morainic drift which nearly everywhere covers the land, attains a thickness exceeding 30 feet, and the underlying rock is often weathered to a great depth. The gold-diggers in these parts distinguish

* *Nuddelanden fron Industria-styrelsenin Finland*, 1902.

three varieties of occurrence: (1) the terrace-gold, in the gravel which covers the slopes and bottoms of the valleys; (2) the bottom-gold (*bottenguld*), on the fissured and uneven surface of the bed-rock underlying the gravel; and (3) the bank-gold, in the "banks" (deltas or fans?) deposited by the rivers at their mouths, as, for example, in the case of the Sotajoki, or at favourable meanders, as, for example, in the case of the Ivalojoki. Occasionally the rivers have cut a new channel through these "banks," and thus repeated the ore-dressing process. The gold-bearing strata are often discernible by a rusty coloration, due to the presence of hydrates of iron. The bank-gold is finer-grained and more waterworn than the other two varieties; in the actual output from the alluvial diggings the terrace-gold bulks by far the most largely. Generally speaking, these auriferous alluvia average some 20 inches in thickness, but in places they attain a maximum of 7 feet or so; in width they do not much exceed 6 feet, although sometimes a width of 50 feet has been proved. The tailings consist chiefly of iron-ore, both magnetic and non-magnetic, and garnet; at some localities monazite and a little zircon also are found in them. The biggest nugget ever got in the district, and that not of pure gold, weighed barely 3 ounces. In the summer of 1905, traces of platinum were observed in several of the placers; and thirty years before that, Dr. G. Svedelius had predicted that the mother-lode would be found not far from traces of platinum, in these localities where the placer-gold is most abundant, is coarsest-grained, and at its highest point above river-level. His predictions have now been verified.

The country-rock of the auriferous lodes may be designated generally as a granulite, although the type varies from place to place. Taking as an example the Vahtamaapää rock, this is a micaless schistose variety, made up of quartz and felspar, interspersed with small garnets, the diameter of which sometimes exceeds an inch. Another variety, rich in biotite, assumes rather the aspect of a granite-gneiss, while here the garnets diminish or disappear. In some cases graphite occurs among the accessory minerals. The granulites are intersected by dykes of coarsely-granular pegmatite, which passes little by little into pure white quartz, and of diabase or basalt. True fissure-dykes of later age traverse the country for miles: they consist of a red fine-grained quartz-porphyry, and their genetic connexion with the auriferous lodes is highly probable. In some localities the pegmatite-quartz dykes have attracted the attention of prospectors because of the occasional occurrence of pyrite in them, but in no instance can they be regarded as the mother-lodes of the placer-gold.

Before proceeding to the description of the lodes, the author directs attention to the climatic difficulties which confront the miner and the explorer in that far northern wilderness. The heavy winter snowfall, the spring thaws, and the frequent deluges of rain in summer sweep whole masses of gravel and sand into the diggings, and drown many an exploration-shaft. Such were the experiences encountered by the author himself in the summer of 1905. Full details are given of sixteen lodes, and they may be summarized as follows: in thickness they average 16 to 20 inches; they strike uniformly north and south, and dip very steeply (75 to 85 degrees) eastward or westward; the structure is frequently brecciated, but sometimes banded, showing the order of deposition of the minerals; and the yield in gold is low, averaging less than 31 grains per ton. The lodes consist primarily of quartz, siderite, calcite, specular iron-ore, magnetite, and pyrite, while magnesite and chalcopyrite are accessory minerals. There are, further, at the gossan or outcrop such decomposition-products as limonite and malachite. In general character the auriferous lodes of Finnish Lapland may be said to differ from any as yet discovered

elsewhere; their relative poverty, as compared with the placers derived from them, leads to the hypothesis that the placer-deposits are largely the outcome of a long period of pre-Glacial erosion and concentration of the gold extracted by natural processes from the lodes. The constitution of the lodes was such as to favour rapid formation of a gossan, and the zone of decomposed ores in pre-Glacial times was probably of considerable depth, but the greater part of it was destroyed by the inland ice during the Glacial period, the gold being scattered over a wide area of morainic drift. But at places where the conditions were favourable, near to the valley of a river . . . . the fragments of the gossan were transported to a point where in the post-Glacial period the renewed ore-dressing began, and so contributed to the formation of the placers. L. L. B.

MANGANIFEROUS AND OTHER ORE-DEPOSITS OF NIZHNE-TAGILSK, RUSSIA.

(1) *Gisements de Manganèse du District minier de Nizhne-Tagnilsk.* *By* N. Yakovlev.

Within the domain of the Nizhne-Tagilsk works, six deposits of manganese-ore, including the Sapalsky mines, are spread over a distance of some 12½ miles. The ore is accompanied by brown hæmatites, and occasionally is found in immediate contact with the Devonian limestones. It appears to have been precipitated from solution in the course of a reaction wherein calcium-carbide was a determining factor. In three of the six deposits the limestones have been contact-metamorphosed by eruptive rocks, and have been so marmorized as to be practically impermeable to water, with obliteration of bedding-planes and joints, in such wise as to form less favourable *loci* for the deposition of manganese than the unmetamorphosed limestones. The two richest ore-deposits are connected with limestones that had undergone folding and fissuring such as to favour the circulation of underground waters and the precipitation of the particles of ore. The manganiferous deposits are not always found near the junction of the Devonian sedimentaries with the hornblendic igneous rocks (syenite, etc.), but sometimes quite in the midst of the latter. The author regards the hornblende as the primary source of the manganese.

(2) *Aperçu géologique du Domaine de Tchernoïstotchinsk, Arrondissement minier de Nijné-Tagnilsk.* *By* A. Krasnopolsky. *Bulletins du Comité géologique, St. Pétersbourg*, 1904, *vol. xxiii., pages* 345-400 *and* 1 *plate* (*map*).

The Chernoistochinsky works are situated south-east of Nizhne-Tagilsk, near the Chernaya, a left-bank tributary of the Tagil river, and the rocks of the domain are predominantly crystalline, sedimentary deposits occurring therein as mere patches. The alluvia along the Tagil are gold-bearing; platinum occurs along the Cháuzhe; magnetite is found among the olivine-rocks and diallage-bearing peridotites of the south-western portion of the domain; there are some unimportant traces of copper-ores; and finally, vast deposits of peat—a material of which the future industrial importance is not perhaps as yet fully realized. L. L. B.

AURIFEROUS DEPOSITS OF SERVIA.

Les Richesses minérales de la Serbie: I. Les Gisements aurifères. *By* Douchan Jovanovitch. *Paris*, 1907, 107 *pages, with* 55 *figures in the text and* 1 *map.*

The author deals with the gold-fields of Pek, Mlava, Porecka and Timok, all situated in Eastern Servia, and separated one from the other by hill-ranges. In that region, many traces of the Roman occupation survive, and among

them those of the ancient gold-workings, and of the mint and goldsmith's furnaces of Viminacium. The history of the mineral-industry hereabouts is given in some detail, and then in the second chapter of his monograph the author describes the geology of the area.

The crystalline schists, which may be regarded as the basement-rocks of the country, form an extensive belt, interrupted in places by outpourings of eruptive rocks of all ages. In the Pek basin, the Palæozoic rocks are seen to overlie directly the crystalline schists, while the most considerable outcrops of Triassic sedimentaries in south-eastern Servia occur at Veta; there is some reason to infer a connexion between the latter and the occurrence of certain metalliferous ores (copper, etc.). Jurassic and Cretaceous sedimentaries are also well represented; while, in the Pek and Timok basins (the latter more especially), the gold-placers consist for the most part of sands and gravels of Tertiary age. Nevertheless, the Quaternary deposits play a more important part still among the Servian placers, their wealth in gold being quite remarkable; and in the Timok basin the great diluvial terraces of loess, gravel, and sand attain a considerable height. Apart from the placers, there are several groups of parallel fault-fissures, infilled with gold-quartz, etc., which are undoubtedly connected with the various periods of vulcanicity through which the region has passed: these fissure-lodes have, generally speaking, a north-and-south strike; but their width is variable, ranging from 5 to 100 feet. They do not appear to have been proved, so far, to a greater depth than 330 feet.

It is more especially to the Tertiary eruptions of the middle period, the andesites, that the author is inclined to attribute the advent in their greatest intensity of the metallic sulphides with the concomitant precious metal. The emanation of auriferous sulphides of copper and iron came to an end in the third eruptive phase, when perhaps there was a correspondingly more intense emanation of sulphides of lead, zinc, and antimony, such as those found at Believina, Bela-Reka, Maidan-Pek, and Kucajna. The products of slow sublimation have been concentrated in the cavities of the limestones, especially at their contact with the andesites; thus, in the Angelina cavern at Kucajna, a mass of 247,170 cubic feet of auriferous lead-ore has been found. The author dwells complacently on the richness of the placer-deposits (sands, gravels, etc.), the metalliferous particles of which are derived from these fissure-lodes, cavities, and pockets; and mentions that the three dredges which are in regular operation at Neresnica, in the Pek valley, are yielding excellent results.

In the third chapter, he gives what he terms a mineralogical synopsis of the subject. A native amalgam of gold, known to the Servian miners as *Zhivak* (from *zhiva*, mercury), occurs in rounded, whitish grains, in association with red granules of cinnabar in the placer-deposits; and, wherever these two minerals are found, there also magnetite appears in great quantity. The alluvial gold of eastern Servia is always more or less argentiferous: it occurs variously as fine dust, in thin flakes, slender needles, granules, and nuggets averaging in size that of a hazel-nut. The importance of the association of gold, in the primary deposits, with the sulphides of copper and iron, has already been hinted at. In the St. Ann mines of Deli-Iovan, for instance, where masses of compact iron-pyrites occur, the richness in gold increases concurrently with the quantity and hardness of these masses, which indeed are cemented together by quartz containing native gold. The average yield, calculated from a vast number of assays of samples from these mines, ranges between 370 and 432 grains per ton. Although the association of chalcopyrite is perhaps generally of less importance in eastern Servia than that of iron-

pyrites for the occurrence of gold, yet in certain districts it takes the premier position, as at Majdanpek (an important copper-mining centre), Bor, and Zlot-Brestovac. The association of the gold with arsenical pyrites, galena, cinnabar, calamine, limonite, magnetite, and quartz, respectively, is discussed; and we then come to the fourth and final chapter, in which the author deals with the geographical distribution of the gold.

Taking first the Pek basin, after a glance at the auriferous localities of Leshnica and Kaona, and a hint that the installation of two gold-dredges in the broad valley of the Pek, between the latter village and Turiya, would pay, a description is given of the Kucajna mines, situate some 22 miles south of the river-port of Veliko-Gradisté on the Danube. Exploration-work has only touched here about a tenth of the total area pegged out, and has not been carried in depth more than 160 feet below the surface; yet there is no question that the deposits are very rich, and the Pek river here would furnish motive-power estimated at 60 horsepower. During the short period that was devoted to mining operations, 270 tons of lead, 33 tons of zinc, 54,687 ounces of silver and 2,765 ounces of gold were got from these mines. The author describes at some length the mining operations which are being carried out by a British company at Neresnica (gold-dredging, as above mentioned) and elsewhere; and statistics are given of the output obtained by means of the dredges in the years 1903 to 1905. The Sveta-Varvara (St. Barbara) mines, on which exploration-work is still in progress, are expected to yield a minimum of 400 grains per ton. The Majdanpek mines, to which allusion has already been made, are in the hands of a Belgian company.

After a brief survey of the Mlava basin, the author passes on to the Porecka-Reka basin, where the only important localities for gold so far known are Crnajka and the neighbourhood of the village of Luka. In regard to the Crnajka valley, the difficulties of working the deposits would be very great, otherwise than by a method of combining excavators and dredges, a combination which has yielded good results in Siberia.

In the Timok basin, the Deli-Iovan deposits, both primary and secondary (or placer-deposits), have already been mentioned. But the Crna-Reka district, where the gold occurs amid the andesites, is of fully equal importance from the miner's point of view, and in the Timok valley itself auriferous deposits extend from Vratarnica up to the head-waters of the river.

A Servian-French vocabulary is given of the principal terms in use among Servian miners, and notice is published that in a second memoir the author will deal with the cupriferous deposits of the country. L. L. B.

MERCURY ORE-DEPOSITS OF AVALA HILL, SERVIA.

Die Quecksilber-Lagerstätten am Avala-Berge in Serbien. *By* H. FISCHER. *Zeitschrift für praktische Geologie*, 1906, *vol. xiv., pages* 245-256, *with* 17 *figures in the text.*

The Avala hill, some 12½ miles south of Belgrade, is built up of unfossiliferous marly limestones of Cretaceous age, traversed at various points by biotite-trachytes. Southward of this hill stretches a serpentine-tract, amid which crop up at six localities rock-masses essentially consisting of chert or of a fine-grained brownish-grey, or white quartz intergrown with ferruginous dolomite (brownspar) and carrying mercury-ores. A characteristic constituent of these rock-masses is the chromiferous potash-mica, described by Dr. — Lossanitsch under the name of avalite. Rather over half a mile to the south-west of Mala Stena (one of the six localities just mentioned), along the Ripanj river, and near the junction between serpentine and limestone, yet

other dolomitic quartzose rock-masses are ranged lineally one behind the other, characterized by an especially high percentage of dolomite, and carrying at one point a small quantity of galena. The quicksilver-ores are only found here in the form of rolled pebbles.

The ore-deposits were discovered in 1882, when the Servian railway, from Belgrade to Nisch, was in course of construction. Up to the year 1887, they were worked only on a small scale, but thenceforward until about 1891, operations were conducted on a fairly large scale. Von Groddeck had, in 1884, described the quartzose masses as lodes: but the adits driven in the course of exploration-work through the rocks, showing the avalite-quartz-masses to be on all sides enveloped by dark-green serpentine, are held to have disproved this view. There seems, however, to be little doubt that the deposits are the outcome of the metamorphic alteration of serpentine by thermal alkaline springs, containing in solution silica and carbonates and so forth; like the original serpentine the quartz-masses contain pisotite, chrome-iron-ore, etc. The adit driven at Schuplja Stena moreover proved the absence of a distinct junction-line between the serpentine and the avalitic dolomite-quartz rock; indeed, the former passes into the latter so gradually, that it was often impossible to tell in the mine where the one began and the other ended.

The author gives a petrographical description of the serpentine and the passage-rock (opalinized serpentine), likening the latter to the matrix wherein the Bohemian garnets occur, with the difference, however, that no olivine is to be found in the Servian rocks here described. Nevertheless, the mesh-structure of the serpentine indicates its probable derivation from a peridotite. The films and granules of cinnabar and the associated specks and crystals of pyrites found in the quartz are connected with fissures which were evidently opened up within the quartz-masses after the metamorphic process was complete. These fissures, varying repeatedly from a mere hair's breadth to a width of 16 inches, are infilled with a gangue of white, coarsely crystalline quartz and heavy spar, in addition to the ores just mentioned: calcite is of rare occurrence. In the immediate neighbourhood of the fissures, the quartz is so strongly impregnated with cinnabar that one may almost speak of pockets or nests of ore; in the fissures themselves cinnabar occurs in granular or crystalline compact masses, and encrusting geodes in the form of lustrous cochineal-red crystals. Calomel, of later formation than the cinnabar, also occurs; and native mercury, in the form of innumerable little globules, is a frequent associate of both minerals. The chronological sequence of the minerals in the fissure-veins would appear to be: (1) quartz, heavy spar, pyrites; (2) cinnabar, mercury oxychloride (?kleinite), calomel, native mercury; (3) younger quartz, younger baryte; and (4) younger cinnabar, younger pyrites. The hypothesis that an enrichment of the ores would be traced in depth has been unfortunately falsified: the richest and most extensive ore-bodies were found at Schuplja Stena at the horizon of the Jerina adit (130 feet below the surface) and at the third 'tween level; but at the deep-level horizon the quantity of ore and its richness in quicksilver proved to be inferior to what had been found at higher levels.

The suspension of mining operations is consequently not due to want of the necessary capital for pursuing exploration-work; but because the deposits are in themselves of small extent, and offer no prospect of any improvement as one goes deeper down. Between 1885 and 1891, it is reckoned that 7,796 tons of ore were got, yielding very nearly 176,000 pounds of metallic mercury.

The genesis of these Servian quicksilver-ore deposits is said to be analogous to that of the Californian deposits. L. L. B.

ORE-DEPOSITS OF THE PROVINCE OF ALMERIA, SPAIN.

(1) *Vorkommen, Gewinnung und Aufbereitung der Blei- und Kupfererze des Pinar de Bédar in Süd-Spanien.* By O. Pütz. *Zeitschrift für das Berg-, Hütten- und Salinen-wesen im preussischen Staate*, 1906, *vol. liv., Abhandlungen, pages* 675-683, *with* 10 *figures in the text.*

The Sierra de Bédar, in south-eastern Spain, is built up of those crystalline schists, belonging to the Middle Archæan division, which play so important a part in the structure of the Spanish sierras as a whole. They probably nowhere occur in their original position, but are highly disturbed and plicated, and often surround masses of foreign rock, into which such bedding as they exhibit appears to pass. Mica is so enormously abundant in them, as often of itself alone to cover wide areas containing quartz only in microscopic inclusions. This characteristic occurrence of mica perhaps explains the absence of actual fissures and overthrusts, whereas plications of every kind in the Sierra de Bédar are past counting. In good hand-specimens, the effects of pressure may be traced into the tiniest venules of the mica. The most numerous rock-masses included among the schists consist of limestones of extremely variable texture and composition, and of gneiss generally exhibiting a fibrous structure.

In the neighbourhood of the village of Bédar, a brown hæmatite-deposit is worked, which is most probably the decomposition-product of a spathic iron-ore formed by metasomatic replacement of limestone. In point of fact, a passage is over and over again distinctly traceable from the partly compact, partly crystalline, dolomitic, marmorized limestone into a brown hæmatite containing 60 per cent. and more of metallic iron. Fine pseudomorphs of limonite after pyrite and siderite occur in this deposit.

Pinar de Bédar, the locality where the copper- and lead-ores have been found, lies in the eastern part of the sierra, towards the sea. The exposed rock consists of highly weathered, occasionally very crumbly, earthy limestone. It is unfossiliferous, and is undoubtedly of Archæan age, as proofs of its intercalation among the crystalline schists are forthcoming. The metalliferous ores occur as impregnation-zones in this limestone, sometimes so poorly mineralized that it takes a very keen eye to detect them. The sole representative of the lead-ores is galena, which is of very widespread occurrence, usually in its well-known cubic crystalline form. The percentage of metallic lead and silver that it contains is extremely variable. The copper-ores are not found as sulphides, but as the carbonates, malachite and azurite, which (like the galena) occur in great abundance and are invariably associated; structurally, they belong as a rule to the compact and earthy varieties, and are seen sometimes with the galena, sometimes apart from it. Their genesis, like that of the brown hæmatite already mentioned, may be traced to the upward percolation of thermal waters charged with carbonic and sulphuric acids, in the moribund phase of comparatively recent volcanic outbursts: the difference being that, whereas the iron-ore metasomatically replaced portions of the fissured limestone, the plumbic and cupric precipitates were deposited in all such cavities and clefts as were available in that rock. From the point of view of horizon, the copper- and lead-ores cannot be said to occupy a definite belt, but are somewhat irregularly distributed. Enrichment can, however, be traced along a general line of strike from north to south. The ores are not traced deep down in a vertical direction, for the fissuring and "cavernosity" of the limestone are but shallow or superficial phenomena, and with increased depth the limestone becomes more compact and barren of ore.

These occurrences are hardly such as to admit of mining operations on

the grand scale; but they are well suited to the system, so beloved of the Spaniards, of leasing out concessions in small parcels to separate lessees or *partidarios*, each of whom works his plot, either with the help of his family or with that of hired labour, on his own account. Thus a great number of small shafts and headings are huddled together in a comparatively restricted area; and winding is performed by means of a wooden hand-winch with esparto-rope, the ore being brought up in baskets, also woven of esparto-grass. The miner is conveyed, sometimes down to depths of 160 feet and more, by the action of the same winch and rope. Boys alone act as hauliers, carrying the ore-baskets on their backs through the low and narrow workings. Many mines, however, are worked opencast; and, where not, they are generally confined to shallow depths and to the loose cavernous limestone. In point of fact, the percentage of attainable profit would hardly repay an extensive use of blasting-materials.

Quite an infinitesimal proportion of the ore thus brought to the surface (and then only the copper-ore) is sufficiently pure to be shipped without further treatment. The overwhelmingly greatest part of the output, including all the galena, has to undergo a preparation for the market, which constitutes really the main work of the mining folk. In view of the small scale on which operations are conducted, this involves, of course, manual labour pure and simple, and some of the most primitive appliances conceivable. But the industry, skill, and punctilious carefulness with which that labour is performed enable the miner to achieve results such as no mechanical appliance could rival. It is true that the losses involved in washing the ore are sufficiently considerable to enable a *partidario* frequently to work with profit over again the tailings or waste-heaps left by his predecessor. The successful results are perhaps especially due to the unshakable perseverance of these Spanish miners, in the monotonous repetition of the various stages of the purifying treatment. This treatment is based on the same principles as those adopted in far larger establishments: hand-picking, trituration, sifting, and washing in appropriate tanks follow one another in chronological order. As a general rule, however, the granular condition in which the stuff reaches the surface precludes hand-picking; and the raw material is thrown at once on to a sieve, consisting usually of iron rods, between each of which is a space measuring 0·8 inch. The material that fails to pass through this sieve is tipped into a circular space some 6½ to 10 feet in diameter, bounded by large stones, and two or three boys, wielding iron crushers, go on for hours rhythmically triturating the material, apparently insensible to fatigue and to the torrid heat of the southern sun. In a few isolated cases, rollers (similar to those used in some German mines) set in motion by a beast of burthen, are employed in the trituration-process. The crushed material is then placed in a sieve, which is worked up and down for half a minute to a minute in a wooden *kasten* containing water, with the result that all the fine particles are precipitated to the bottom of the *kasten* or recipient. The coarse ore remaining in the sieve is raked off, and subsequently resifted as many times as may be necessary. When sufficient fine ore has collected at the bottom of the *kasten* or *estanque*, the water is drained off, and the ore is accumulated in a heap, until there is enough of it got together for the process of final washing on a rimmed plank-flooring which rests simply on the surface of the ground. Water is introduced through an opening in the rim, an inch or two above the floor-level, and the pulverized ore is stirred up in the water which streams across the slightly inclined floor into a settling-tank by a man wielding a sort of long-handled hook (*rodillo*). Apparently the system is so contrived

that the same water is used over and over again. Without following the author further into the detailed description which he gives of this stage of the process, it may be sufficient to note that it results in a considerable enrichment of quite poor ores, amounting to as much as 40 or 50 per cent. on an average. The daily output per man employed in this very tedious work hardly exceeds 40 pounds of ore, remembering that the labour-day is one of 12 hours, and that work is done on Sundays, just as on week-days. When it is a question of piece-work, as in the industry here dealt with, the Spaniard is diligent beyond cavil, and, furthermore, his temperate habits are well known.

(2) *Über einige Erzlagerstätten der Provinz Almeria in Spanien.* *By* BARON F. FIRCKS. *Zeitschrift für praktische Geologie*, 1906, *vol. xiv., pages* 142-150, *with 5 figures in the text.*

Geologically speaking, the province of Almeria, at the south-eastern extremity of Spain, is built up of Archæan schists, Triassic and later rocks, and sub-recent deposits. Older eruptive rocks play a secondary part among the schists, while the newer eruptives, following a great fissure- and fault-line, strike along a belt parallel with the coast from Cabo de Gata to Cabo de Palos, a distance of 125 miles. There is an undoubted connexion, between the occurrence of the metalliferous ores in these parts, and the younger eruptives and the associated hydrothermal phenomena. It was amidst the flows of andesite, dacite, liparite, and trachyte that the Carthaginians and the ancient Romans pursued active mining operations; and, after generations of death-like torpor, the mineral-industry hereabouts has recently sprung into vigorous life again.

After a brief sketch of the general geology of the region, the author proceeds to describe the galena, copper, and iron-ore-deposits of the Sierra de Bédar and of Coscojares, those of the sierra being by far the most important. Here galena and carbonates of copper form the cementing-material of a limestone-breccia, whereas the oxidic iron-ores are intercalated as a bedded deposit between a marmorized limestone and the gneissose mica-schists. The wealth of lead- and copper-ore diminishes notably in depth, and the deepest workings hardly go beyond 325 feet down. Trial-shafts pushed to a greater depth have struck very feebly metalliferous limestone. The galena hardly ever occurs in a decomposed condition, or altered to carbonate; while, on the other hand, the sulphidic ores of copper have never been found, their carbonates only being known here. Veins of barytes traverse the limestone in many places, and are frequently carriers of copper-ore. The proportion of silver in the galena varies enormously; where the galena occurs alone there are barely 11 ounces of silver in a ton of 50 per cent. lead-ore, but where copper-ores are associated with the lead, as much as 32 ounces of silver may be found in the ton of ore. The nature of the occurrence is such that it favours individual working on a small scale, and when good prices are obtainable a total monthly output (from about 200 workings operated by manual labour exclusively) of 300 tons of 45 per cent. galena and 250 tons of copper-ore containing 5 per cent. of the metal, may be reached. There seems to be no doubt that the origin of these ores dates from the older Quaternary time, when thermal springs (some of which are still in existence) made their way up through clefts and fissures in the eruptive rocks, and, rebuffed by the recalcitrant schists, deposited their metalliferous particles among more easily attackable rocks, such as limestone. That the plumbiferous solutions, at any rate, did not actually decompose the limestone is evident, since the fragments of breccia cemented by lead-ore have preserved their original angularity.

West of the galena-mines of the Pinar de Bédar, lie the neighbouring iron-ore workings of Serena, the geological relationships of the latter being all but identical with those of the former, although there is perhaps more evidence of disturbance and faulting. The main bed of limestone here averages 65 to 100 feet in thickness, occasionally much exceeding this, and sometimes also pinching out to nothing. In places it is overlain by thin bands of Triassic limestone and conglomerate, showing here again an analogy to the Pinar de Bédar occurrence. The limestones intercalated among the schists are the carriers of the iron-ore, the richest accumulations being usually at the junction of the two rocks (schist and limestone); but this by no means implies that the contact-zone generally is mineralized. In relation to its total extent, in fact, the mineralized portion is quite small. Where mining operations, however, are now in full activity, practically a third of the contact-zone proves to be workable. In the deep-level workings, the thickness of payable ore varies from 10 to 16½ feet. Apart from the contact-zone, certain portions of the limestone itself appear to have passed by metasomatosis into iron-ore. The payable stuff may be defined as consisting of the several varieties of brown iron-ore, with which are secondarily associated such minerals as pseudomorphs of limonite after pyrites and siderite, native copper, malachite, barytes, etc. The working is done by pillar-and-stall; and, on account of the rotten condition of the roof, a very complete system of packing has to be resorted to. The ores are carried down by means of a Pohlig cable-railway, 10 miles in length, to the harbour of Garucha, where they are put on board ship. The average annual output from 1893 to 1903 inclusive has been 100,000 tons. The crude ore of the opencast workings assays to 48 per cent. of metallic iron and 15 per cent. of silica; the normal ore averages 58 per cent. of iron and 3 to 5 of silica.

Northward of the Serena mines, lie a vast number of concessions of which only a portion is worked, the most important being perhaps the Tres Amigos and La Feria mines.

It seems evident that these brown iron-ores are in almost every case the decomposed outcrops of deposits of spathic iron-ore, which latter have been formed by metasomatosis. They are not to be regarded as the ferruginous gossans of lead, silver, and copper-ore-deposits; and it is highly probable that the singularly uniform belt of iron-ore-deposits, which extends along the shores of the Mediterranean (eastern coast of Spain and northern coast of Africa) and along the western coast of France, owes its origin to the upwelling of thermal ferruginous solutions at an epoch quite distinct from that during which the other metalliferous ores were formed: yet, although distinct, it was not perhaps very much earlier.

(3) *Über einige Erzlagerstätten der Provinz Almeria in Spanien.* [*Part II.*] *By* Baron F. Fircks. *Zeitschrift für praktische Geologie*, 1906, *vol. xiv., pages* 233-236, *with* 1 *figure in the text.*

As in almost every other mining district in Spain, the ancient Romans were the first to prospect and work over the ore-deposits of the Sierra Almagrera (province of Almeria). After many vicissitudes there has been of late a revival of the mineral-industry in that neighbourhood, in part owing to the success with which German engineers have solved the problem of unwatering the workings. The sierra ranges for over 5½ miles, sensibly parallel with the coast, to which it presents a steep scarp, and reaches its greatest altitude (1,200 feet) in the Puntal del Ruso. Somewhat less than 2½ miles in breadth, the sierra is largely built up of phyllites, in part metamorphosed, from among which rise here and there wall-like reefs of quartz. Banked up against the

spurs of the sierra are the Tertiary limestones, marly and sandy clays, sandstones, and conglomerates, while the western flank of the range is characterized by a belt of younger eruptive rocks which appear to be the ore-carriers. The metalliferous lodes all but universally strike north-west and south-east (the sierra trends from north-east to south-west) with a north-easterly dip, but their longitudinal extent rarely exceeds a thousand yards or so. In point of fact, two complexes of lodes can be traced, of which the older is by far the richest and the most important; while the newer, in many respects, not least in the low percentage of silver, recalls the sulphidic lead-veins of Freiberg. The principal ore is a highly argentiferous galena, almost everywhere occurring in the form of octahedral crystals. Pyrites, blende, and the fairly abundant bournonite play a secondary part. Nearer the surface native silver, and its combinations with chlorine and iodine, as also copper-pyrites and its decomposition-products, are met with. The gangue chiefly consists of yellow chalybite, heavy spar, and fragments of the country-rock; calcite occurs as an accessory. In several mines the chalybite occurs in such quantity and of so pure a quality, that it pays to work it as an iron-ore and smelt it for export. In some cases there is so microscopically minute an intermixture of the chalybite and galena (locally termed *molineras*), that the observer might well rush to the conclusion that he has before him a new mineral, hitherto unrecorded. The richest ores, perhaps, have been got at middling depths, reckoning from 328 feet below the surface to the underground water-level of the country. The two most important localities in the sierra (from the miner's point of view) are in the Jaroso valley and in the Franzes valley. Here are found the highest percentages of silver and the richest lead-ores, while as one recedes from them the ores are seen to pass into pyrites and poorer galena, and gradually to disappear altogether. The best lodes occur on the eastern flank and on the crest of the sierra, while on the seaward scarp the lodes are few in number and insignificant in quality. The Jaroso main lode is known to extend over 2,000 feet, it is 33 feet thick, and has yielded by far the greater portion of the total lead and silver output of the district.

The iron- and silver-ore-deposits of Herrerias, situated at the base of the Sierra Almagrera, are as closely connected with that sierra from the geological standpoint as they are from the topographical. The phyllites, masked here by Triassic limestones and shales, these again being mantled over by Tertiary loams and conglomerates, are struck at Herrerias ($1\frac{1}{4}$ miles distant from the sierra) at a depth of 650 feet below the surface. The principal ore of this district is an iron-ore remarkable for the high percentage of manganese which it contains. The richer ores, assaying to 50 or 60 per cent. of metallic iron and 6 per cent. of manganese, are nearly always in a soft, crumbly condition, while the poorer ores, hard and coarse-grained, occur wherever the compression of the limestone has been incomplete. The ore-deposit, associated as it is with the contact-zone of limestone and shale, is of metasomatic origin, like most other iron-ore-deposits of the province of Almeria, recalling indeed those of Bédar, previously described by the author.

The occurrence of rich silver-ores and native silver is of supreme importance for the Herrerias district. Frequently does it happen that an iron-ore deposit is overlain by loamy beds which are so impregnated with silver-ores that samples have yielded a *minimum* of 100 parts of metallic silver per million (3·2 ounces per ton). The sandy layers are not seldom highly silicified, and in such cases are particularly rich in silver. The iron-ore itself is seamed by a number of veins and venules, mostly infilled with heavy-spar, which

ramify and nip-out in the overlying loamy beds. The silver-ores are undoubtedly derived from thermal springs similar to those which formed the Almagrera lodes. The succession of events was probably somewhat as follows:—Upward percolating ferruginous solutions transformed the limestone into carbonate of iron, and accessorily into sulphides of iron. This metamorphosis was naturally most active where the way lay most open to the ferruginous solutions, that is, at the contact between limestone and shale. The iron-ore deposit having been formed, further mountain-movement took place with consequent fissuring. Long fissures were easily opened up in the slates of the Sierra Almagrera, but encountered another sort of obstacle in the altered and originally soft deposits of Herrerias; here, therefore, a network of fragmentary lodes was formed rather than a regular series of big lodes, although the mineralogical composition of the former is practically identical with that of the latter. If lodes were formed with difficulty among the iron-ores and limestones of Herrerias, still more would that be the case with the overlying loamy deposits: in these no fissures could properly form, and intimate impregnation with silver-ores was the consequent alternative. At Herrerias, as in the Sierra Almagrera, evidences of the mining industry of the ancient Romans abound. About the middle of the nineteenth century, as in the case of the Sierra Almagrera, there was an industrial revival which lasted for several years; nowadays, however, there is a woeful falling-off, and but few mines can boast an output of much importance as regards silver-ores. In regard to the iron-mines, it is another story altogether—quite a number produce large quantities of ore, and there are prospects of a still greater output for many years to come. L. L. B.

HUELVA PYRITES-DEPOSITS, SPAIN.

Beiträge zur Kenntniss der Huelvaner Kieslagerstätten. *By* Bruno Wetzig. *Zeitschrift für praktische Geologie*, 1906, *vol. xiv., pages* 173-186, *with* 13 *figures in the text.*

It would seem that the scientific description of these deposits, so far as well-digested published matter is concerned, has hardly kept pace with the extraordinary activity of the mining operations of which they are the object. So rapidly are they being worked that the author fears, that in the case of many a mine, the last shift will have completed its task ere the man of science finds the opportunity of gleaning his own little harvest of data as to exposures, etc., therefrom. Much printing-ink has, it is true, been expended on Huelva (more especially on Rio Tinto), mostly in the form of traveller's impressions hurriedly jotted down in the course of a few days' visit. Perhaps the only solid contributions that have been made to the knowledge of the subject within the last twenty-five years are the accounts published by Messrs. J. H. L. Vogt, Klockmann, and Gonzalo y Tarin respectively. The theory of the sedimentary origin of the deposits enunciated by the second of the above-mentioned authors appears to have held the field until recently; but now that the champions of an epigenetic or metasomatic origin have entered the lists, Mr. Wetzig thinks it incumbent upon him to break a lance with them. Dight in the full panoply of notes and sketches, amassed in the course of a quarter of a century's residence in the province of Huelva, during five years of which he lived at the mines and almost every day was in and about them in his capacity of engineer, he enters the fray with a justifiable assurance of victory. He points out that it is rather an advantage that his own observations bear mostly on the smaller mines, as it is in these smaller mines that

the general conditions can best be grasped and studied as a whole. The gigantic scale of everything in the larger mines renders a bird's-eye view of the subject all but impossible.

The masses of pyrites occur on a plateau consisting chiefly of shales and apparently-stratified eruptive diabasic rocks, with a little grauwacke, and still more rarely limestone, rising towards the Sierra de Aracena to an altitude exceeding 1,300 feet above sea-level. The rocks have been much overthrust and disturbed, their general strike is from east to west, and they dip almost invariably northward. The plateau is a plain of erosion, on the whole undulating with deep-cut river-valleys, while the hills which rise from it like islands are mostly built up of quartz or jasper, and have thus opposed a stout resistance to the agents of denudation. Recently, the well-known fossil *Posidonomya Becheri* has been found in various localities in the mining field; and the author regards it as extremely probable that all the rocks date from the period of the Kulm, although he afterwards says that certain eruptives rich in quartz which have affected the ore-body at the contact are undoubtedly of later age than the diabasic sills which have not affected the ore-body. Thus at San Telmo intrusive porphyries have twisted the strike of the pyrites-deposits and the neighbouring shales almost right round from east-and-west to north-and-south; at the Joya mine the columnar porphyry cuts through the centre of the ore-body, laying the western portion of it flat and squeezing the eastern portion into a pillowy mass. At La Caridad in Aznalcollar, the ore-body, which assumes the character of a seam, is repeatedly fissure-faulted in its western portion, while in the eastern portion where the porphyry comes into contact with the ore-deposit, the latter is nipped out or packed into folds.

The imposing spectacle of the great masses of ore of Rio Tinto and Tharsis, hundreds of feet thick, is apt to delude the observer into a belief in the complete unity of character and structure of the deposits. But a closer view reveals the existence of separate beds and lenticles of ore, alternating with wedges or lenticles of barren shale (*cuña de esteril*). Certain beds of ore are characterized by a higher percentage of lead and zinc, and some take on quite a banded structure, owing to the alternation of pyrites, blende, and galena, these bands being always parallel with the bedding. Other beds are characterized by a high percentage of copper in the form of chalcopyrite, and a consequently yellow coloration; yet others, on the contrary, consist of a very compact ore, containing but little copper and a high percentage of sulphur. Occasionally the pyrites is so interbanded with fine laminæ of shale, that it assumes all the appearance of the latter, and its true nature is only revealed by its specific gravity. Sometimes the shale predominates over the pyrites, such masses being known as *azufrones*; and there are some ores which are very difficult to break up, owing to the large amount of quartz associated with them. All the ore-bodies coincide in strike and dip with the shales among which they lie; they partake, too, in all the plications and disturbances to which the latter have, in the course of ages, been subjected. Particular belts of ore-bodies can be followed along the strike of the shales, such as that extending over a length of about 3 miles, which is worked in the mines of Carpio, Cruzadillo, Poytos, and Lomero. The several deposits are linked one with the other by brown ferruginous shales, which in depth prove to be impregnated with pyrites, and occasionally exhibit stringers or beds of massive pure pyrites. The author cites various other examples of similar ore-belts, and proceeds to point out the hopelessness of endeavouring, either to lay down rules as to the relation between the thickness of any of these

deposits and the amount of copper which they contain, or to calculate the form and extent of the lenticles by means of mathematical formulæ. On the other hand, the enrichment in copper of a given deposit may be gauged from the thickness of the ferruginous gossan which overlies it, taking also into account the amount of erosion which that gossan has demonstrably undergone. It is shown, too, how the richest copper-ore may be expected to occur rather at the floor, than at the roof, of a deposit; how, further, enrichment has sometimes taken place along fissures and clefts, which cut across the deposit transversely to the bedding. The miner translates the enrichment of the upper zones of a deposit which has a ferruginous gossan at the outcrop into terms of impoverishment with depth; thus, at Cabezas del Pasto, the ore at the 130-feet level contained on an average $3\frac{1}{2}$ per cent. of copper, whereas at the 260-feet level it contained only 2 per cent. In the Caridad mine at Aznalcollar, the ore at the 130-feet level contained from 4 to 5 per cent. of copper, but at the 360-feet level only a half per cent. At Cuchichon, however, after impoverishment between the depths of 260 and 375 feet, an enrichment of the ore was observed thenceforward down to the greatest depth reached in the mine, that is, 500 feet; but this apparent exception is explained by a diagram. The author combats strongly the views of those who do not regard the ferruginous gossan as purely and simply the decomposition-product of the pyrites. He shows how the nature of the gossan is an index to the character of the underlying ore-body; where the former is a compact red hæmatite, the underlying pyrites is compact and poor in copper; where the gossan is yellow, porous, and ochreous, pyrites rich in copper may be looked for beneath it.

A deposit known as *toba*, bears in appearance an extraordinary resemblance to the gossan, and is often confused with it. The *toba* was formed in this way: the iron-sulphate waters, leached out of the original mass of pyrites, banked up in pools or lagoons, deposited their iron-oxide around pebbles of quartz and shale on the bottom, and thus a conglomerate with a ferruginous cement was built up. The gossan, on the other hand, would answer the description of a breccia of iron-oxides cemented by infiltrated silica. The *toba*, as a secondary deposit, does not occur on the spot where its materials were formed, and naturally coincides neither in strike nor in dip with the shales. It has been the cause of many erroneous notions as to the genesis of the ore-deposits. At the Rio Tinto mines, the *toba* forms a great plateau, the Mesa de los Pinos, in which remains and impressions of Tertiary plants are found. In the Caridad mine, the *toba* is seen to stand up in isolated reefs among the Eocene limestones, and is also seen to have been thrust downwards by the intrusive porphyry to a depth of 230 feet. At the same mine, conclusive evidence of the pre-Tertiary age of the ore-body is thus available, since, apart from what has just been said about the *toba*, the Eocene horizontally-bedded limestones overlie unconformably the uptilted ore-beds and shales. Data are also adduced from the Aznalcollar mines, to show that, in comparison with the age of the Huelva pyrites-deposits, the interval of time that has elapsed since the deposition of the Eocene limestones is of small account, so small indeed that the progress of the decomposition of the original ore into oxides of iron is hardly noticeable in that interval.

Recurring to the question of the genesis of the pyrites-deposits, the author holds that all the facts, of which a synopsis has just been given, constitute cumulative evidence in favour of the sedimentation-theory. He enumerates the several particulars which go to prove that the deposits cannot be lodes or infilled fissures, and then refers to the observed gradation from pure pyrites,

through more or less impregnated to absolutely barren shales, as further proof of the sedimentary origin of the ores. At the Monte Rubio mine, and near the hill of the Virgen de la Peña, at La Puebla de Guzman, the ore-body consists of shales strongly impregnated with pyrites, alternating with thin stringers and bands of pure pyrites, none of which exceeds 3 feet in thickness. The composition of the ore is identical with that of all the other pyrites-deposits in the province, only the accumulation of the pyrites has not been carried to the same pitch of concentration. Several similar instances are cited, all showing more or less the above-mentioned gradation.

The extraordinary shapes which the deposits occasionally assume, capricious as they were termed in the older text-books, are doubtless due in part to the subsequent intrusion of eruptive rocks, and in part to the dynamical effects of pressure and thrust.

In conclusion, the author devotes a few lines to the manganiferous deposits of Huelva. These occur in the same formation as the pyrites-deposits, and, like them, are conformably interbedded with the shales. In fact, all the conditions of their occurrence are remarkably similar, with the difference that the manganese-ores do not appear to continue in depth much beyond 65 feet below the surface. Very rarely do they attain a depth of 130 feet, and in the single instance of the Santa Catalina mine, close to the deep-cut river-bed of the Guadiana, was manganese-ore still found at a depth of 330 feet. About 15 years ago, however, it was discovered that the above-mentioned exhaustion in depth of the manganiferous deposits in reality applied only to the oxides of manganese; but that silicates and carbonates of manganese (in incomparably greater quantity) occur down to considerable depths, in beds and lenticles similar in structure and succession to the pyrites-deposits, and alternating just as these do with the shales. The carbonate and silicate of manganese are undoubtedly primary deposits of sedimentary origin, while the superficially occurring pyrolusite and the associated jasper are secondary deposits—the alteration-products indeed, of the others and in a sense comparable with the ferruginous gossan of the pyrites-deposits. L. L. B.

ARGENTIFEROUS GALENA OF CADLIMO, SWITZERLAND.

Sul Giacimento di Galena argentifera dell' Altopiano di Cadlimo. By E. Mariani. *Giornale di Geologia pratica*, 1906, *vol. iv., pages* 94-98, *with* 1 *figure in the text.*

The high *alp* or Piatto di Cadlimo, lies among the mountains which form the eastern wing of the St. Gotthard group, in the commune of Quinto, district of Leventina, canton Ticino. The rocks hereabouts consist essentially of gneisses alternating with mica-schists, striking on the whole east and west, and dipping northward at 45 degrees or so. The galena-deposit occurs somewhere about the middle of the area described, and prospecting-work was started on it in the summer of 1904 by an American company, which had obtained a concession from the cantonal authorities. The existence of the deposit had long been known, and more or less spasmodic investigations had been made at various times, but the earlier prospectors were hampered by the lack of means of transport and easy communication with the main valley of the Ticino. The spot lies for a great part of the year buried in snow, and was high up away (until quite recently) from any road that could be regarded as really suitable for wheeled traffic. Now, however, a good road has been made up from the Piora valley to the Piatto di Cadlimo, and temporary dwellings and stores have been constructed for the use of the men who are to open up the mine.

The author visited the spot in September, 1905, under the auspices of the engineer-in-charge, and had the opportunity of examining a great deal of material which had been brought to bank in the course of the recent exploration-work. The gneiss-and-mica-schist complex is hereabouts traversed by a number of fissures generally striking from south to north, and narrowing somewhat near the surface; some of them pitch steeply westward, others eastward, and yet others are vertical. The argentiferous galena, irregularly intermingled with gangue, fills up these fissures. The gangue appears to be made up of highly decomposed fragments of the country-rock, with an argillaceous film. The galena occurs in splendidly lustrous masses showing well the cubic cleavage, and also in "granular masses," really made up of big nodules, consisting, in concentric alternation, of bands of galena, mica, and quartz. Various chemical analyses show that the percentage of metallic lead in the ore exceeds 77·65, while the amount of silver varies from 7·78 to 10·25 ounces per ton; but the author considers that a much greater number of samples must be subjected to analysis, before it will be possible to form a definite idea of the exact industrial value of the deposit. The galena is also dispersed through the very smallest cracks that radiate from the principal fissures, in such wise that the country-rock at many places appears to be impregnated with the ore. As the veins of galena crop out at many distinct points, and remain for some distance parallel one with the other, the idea suggests itself that they converge in depth into one great ore-body. At an altitude of 8,364 feet above sea-level, mining operations will hardly prove possible throughout the year, and yet the author thinks that work may go on there during as many as 300 days out of the 365. L. L. B.

MINERAL-RESOURCES OF ASIA MINOR.

(1) *Die Gewinnung nutzbarer Mineralien in Kleinasien während des Alterthums.* By Fr. Freise. *Zeitschrift für praktische Geologie*, 1906, *vol. xiv.*, *pages* 277-284.

The colonies founded in Asia Minor by the ancient civilized peoples of Egypt and Asia were essentially mining colonies, and so the mineral-industry (including metallurgy), even in very remote ages, attained a high degree of prosperity in the Levant. Two points are worth bearing in mind: (1) that the total quantity of metal in use in those days was infinitesimally small, in comparison with that required by the necessities of modern civilization, and consequently mines and smelting-works were conducted on a correspondingly smaller scale; (2) that metals had a far higher value in relation to manual labour (then mostly slave-labour) than nowadays. Thus it was possible in ancient times to mine at a profit deposits which would now be absolutely unworkable, despite the enormous progress that has meanwhile been made in all the technicalities of mining: since metals are lower, and manual labour is higher, in value. This consideration should weigh with the modern prospector, when he suggests the resumption of mining operations on deposits which were formerly remunerative.

The ancients, in hewing out the ores of which they could make use, left calamine and zinc-blende severely alone, as they were unfamiliar with the methods of extracting zinc, especially from the latter ore. The mineral-industry, flourishing under the Lydian kings, the Romans, and the Byzantine emperors, rapidly declined after the Osmanli conquest, and remained in a state of paralysis for five centuries, with the exception of the silver-ore mining carried on at Gümüsh-Khane in northern Asia Minor, and the copper-ore workings of Arghana-Maaden in Kurdistan.

A short general sketch is given of the history of the sub-continent, and then the author enters into details, gleaned from various classical writers, as to the minerals obtained and worked in Phrygia, Mysia, Lydia, Caria, and Lycia (forming now the vilayets of Khodawendikjar and Aidin). Thereafter he glances at the islands lying off the western coast: Lemnos, Lesbos, Samos, and Rhodes; and then at the region which practically constitutes the vilayet of Konia—the ancient Pisidia, Pamphylia, Lycaonia, and Cilicia, completing his survey of Asia Minor with the northern portion thereof, including Bithynia, Paphlagonia, Pontus, Cappadocia, and Galatia. He regards Cyprus and Crete as coming geographically within his purview, and notes that the copper-ores of the former island originated the very name of the metal (*cyprium*, *cuprum*) in all civilized languages.

(2) *Bodenschätze und Bergbau Kleinasiens.* *By* C. Schmeisser. *Zeitschrift für praktische Geologie*, 1906, *vol. xiv.*, *pages* 186-196, *with a map in the text.*

Geological investigations in Asia Minor have hardly been pushed far enough as yet, to permit of an accurate general view of the subject. It is sufficient for the present to state that samples of the formations of all ages, from the Archæan down to the most recent, are of more or less extensive occurrence, but that next to the great crystalline mass (Prof. A. Philippson's Lydian massif) of the central region, Tertiary deposits predominate overwhelmingly. Relying for a geographical and geological description of Asia Minor on one or two lengthy quotations from Prof. Philippson, the author gives details of the occurrence of useful minerals in the following order:—

Meerschaum is found in a soft tufaceous breccüiform rock, grey to reddish-brown, at the base of the serpentine-hills which rise south and south-east of Mount Olympus in the vilayet of Brussa. The mineral is probably an alteration-product of the magnesite which forms a complex network of veins in the serpentine. In place the meerschaum is grey, soapy, and very soft, but soon hardens after its extraction (in lumps of the size of about an apple) from the matrix, and becomes paler in colour. The meerschaum-deposits lie east of Eskishehir in the Pursak valley, where near the river they attain a maximum thickness of 233 feet, thinning away towards the hills, and finally nipping-out altogether. Within an area of barely 2 miles in diameter in that valley, as many as 4,000 shafts have been sunk; but the method of working is far from economic, as mining operations are conducted by a great number of lessees, each employing a very few men. The lessees pay a tax of 15 per cent. to the Ottoman Government, the annual output of 150 tons or so having been for many years exported in its entirety to Vienna.

Pandermite, a borate of lime nearly related to borax, has received its name from the shipping harbour of Panderma on the Sea of Marmora. The best-known deposit of the mineral occurs some 43 miles south of the sea-coast and 18½ miles north-east of Balikesri, at Sultanchaïr, in the form of dazzling white masses, varying in size from a pin's head up to blocks weighing ½ ton or so, within a bed of gypsiferous clay, some 115 feet thick. The mineral appears to be of volcanic origin, and to have been brought by means of springs into an extensive lake-basin. American competition has proved, of late, highly detrimental: the output, which at one time averaged 200 tons of 25 to 30 per cent. pandermite daily, sank in 1903 to 6,000 tons for the whole year. The price, too, has gone down to such an extent that the profits of working the Sultanchaïr mines average barely 5 per cent.

Salt is evaporated from rich brines at Giabul in the vilayet of Aleppo, and from saltings at various points along the sea-coast. It is also got from the great salt-lake of Tutz-Chöllü in Lycaonia. Rock-salt-deposits, 130 feet

or more in thickness, are worked at Tutz-Kiöi, near Nevshehir, and three other localities where the same mineral is worked are mentioned.

Of the numerous deposits of emery, more especially abundant in the vilayet of Smyrna, comparatively few are being worked at present. The mineral usually occurs as a secondary deposit in a brecciated form in a reddish-brown earth, or intermingled with fragments of limestone embedded in earthy limestone in far-stretching cavities or fissures among the crystalline limestones. The greatest known cavernous deposit of this nature is about 330 feet long, 66 feet wide, and 33 feet high. The mineral is worked both opencast and underground, and the crude material is sorted by hand: the percentage of corundum therein varies between 40 and 57. The annual output ranges from 17,000 to 20,000 tons, and is mostly absorbed by Great Britain, the United States, and Germany.

Chrome-iron-ore is the most important iron-ore that Asia Minor can show: it is said to exist there in quantity sufficient to supply the world's markets for generations to come. The known deposits may be grouped in three well-defined areas: (1) the north-western, in the province of Brussa, in the vicinity of Mount Olympus; (2) the south-western, including the districts of Denizly and Makry, and the shores of the Gulf of Adalia; and (3) the south-eastern, around the Gulf of Alexandretta, in the district of the same name and in that of Adana. Careful prospecting will no doubt reveal in time further deposits of the ore in the remoter provinces. In the region of Brussa, the chromite is, like the meerschaum, associated with serpentine as its original matrix. It occurs irregularly therein in the form of flattish lenticles, stringers, pockets, etc., often traversed by faults; more than 120 such occurrences have been recorded, among them that of Daghhardy, 12½ miles south of Chardy, said to be the biggest and richest of the kind in the whole world. Here about 10 million tons of ore, containing from 51 to 55 per cent. of chromic oxide, are in sight. The export of chrome-iron-ore from Asia Minor has in recent years amounted to 40,000 tons per annum, and the output up till the year 1903, at any rate, equalled that of all other countries taken together; but New Caledonia is proving a formidable competitor.

Iron- and manganese-ores are doubtless of widespread occurrence in Asia Minor, but the economic conditions are such that few of them can be worked at present, and those chiefly perhaps in the vilayet of Smyrna. At Rasheya in Syria, north of Mount Hermon, the working of the iron-ore-deposits is facilitated by the occurrence at the same locality of seams of lignite. Cinnabar and gold and silver-ores have been found, again in the richly-mineralized vilayet of Smyrna.

In Asia Minor, the oft-repeated axiom that plumbiferous ores need to be argentiferous as well, in order to repay working, holds good once more. The lead ores are more especially found in those districts where eruptive rocks have invaded the sedimentary deposits. Three such areas are distinguishable; the eastern, western, and southern. To the first-named belong about 15 deposits between Zara and Karahissar in the vilayet of Sivas; to the second the great mines of Balia and Menteshderé; and to the last-named the great Government mines on the southern flank of the Bulgar-Dagh, besides many other localities enumerated by the author.

The copper-ores are conveniently grouped in a north-eastern and a south-western area, whereof the latter is of far less importance than the former. First and foremost in the north-eastern area may be mentioned the mines of Arghana Madén, between Kharput and Diarbekir, not far from the Lake of Giöldjik where the Tigris takes its rise: Naumann's description of them

is quoted, and the author adds that the mines are most wastefully worked by a number of small capitalists, who farm them from the Turkish Government. It seems possible that the authorities will refuse to allow this to continue much longer, and that a chance will be given to syndicates powerfully backed by a sufficiency of capital to conduct operations economically on a large scale. The one drawback is the scarcity of fuel. The hinterland of Trebizonde and Sinope respectively, is also rich in copper-ores. The south-western group includes the mines of Bulbuderé, Assarli, and Cos in the vilayet of Smyrna, and the apparently rich deposits of Tokad and Kalabak, near Balikesri. The total output of Turkish copper-ores for the year 1902 amounted to 1,118 tons.

Antimony-ores occur in the vilayets of Brussa, Smyrna, and Sivas, and are in part worked, but the statistics of output, etc., are said to be exceptionally unreliable. Arsenical pyrites is largely worked in the vilayet of Smyrna for the sake of the gold which it contains, rather than for the arsenic. Occurrences of calamine, native sulphur, and alum are also enumerated.

The coal-deposits on the shores of the Black Sea are of especial importance for Asia Minor. They extend over a belt of a maximum width of 6¼ miles, from Bender Eregli eastward to Amasra. Many of the seams are from 10 to 13 feet thick, they dip as a rule not more than 10 or 12 degrees, and crop out at the surface. They are worked by adits following the dip, until the inflow of water compels the abandonment of these primitive mining operations. The coal is said to be suitable for metallurgical purposes, for coking, and for firing boilers. The Turkish Government works that portion of the coal-field which lies within the Imperial domain, for the supply of the fleet and the arsenals, and if the authorities could only bring themselves to lease the remainder to syndicates prepared to work the coal by the most approved modern methods, an immense development of the mineral-industry hereabouts would ensue. Few concessions have been granted up to the present, the most important being that of the Heraklea company, whose output for the year 1900 amounted to 255,000 tons. The new harbour of Songuldac is being built for shipping the coal. About 35 or 40 miles north-west of Erzerum, a very sandy impure coal is worked by means of adits, but the quality may be found to improve in depth. Other occurrences are cited, which lead to the inference that productive coal-measures extend more or less continuously very nearly to the Persian frontier. At Namrun, 12 hours' camel-ride from Mersina in the province of Adana, coal is being worked by a German lessee.

Brown coal is of widespread occurrence, and as wood-fuel is scarce on the high plateaux, the deposits, where sufficiently rich, should prove of more than local importance. Finally, the author enumerates occurrences of petroleum, asphalt, and bituminous limestones (the Dead-Sea region being extensively cited in connexion with all three), phosphates, fullers' earth, soapstone, lithographic slates, and opal.

There seems to be no question that a systematic geological survey of Asia Minor would vastly extend the known occurrences of useful minerals. The economic and legal conditions of the country are, however, at present so unfavourable, that nothing short of revolutionary changes can effect the complete utilization of its mineral resources. As might be expected from a writer of the author's nationality, due stress is laid on the importance of the Baghdad railway as a new factor which makes for progress. Moreover, the Anatolian Railway Company have been authorized to work any mineral-deposits which they may discover for 12½ miles on either side of the Baghdad line.

L. L. B.

COAL-BEARING BEDS OF FUSHUN, SOUTHERN MANCHURIA.

Fossile Pflanzen aus den Kohlenlagern von Fuschun in der südlichen Mandshurei. By J. Palibin. *Zapiski Imperatorskago S.-Peterburgskago Mineralogicheskago Obtshestva, series* 2, 1906, *vol. xliv., pages* 419-434, *with* 12 *figures in the text.*

This paper is largely devoted to a description of the plant-remains collected by Dr. J. Edelstein in 1903, in one of the richest coal-fields of southern Manchuria, in the Fushantshun collieries, at the small Chinese town of that name, situated on the right bank of the Khunho, some 25 miles east of Mukden. Dr. Edelstein has published the chief results of his researches in the Russian language.* The coal-belt to which special reference is here made extends for some 5 miles along the high left bank of the Khunho, and is cut across midway by the deep but narrow gorge of the Yanbaipu. The rocks of which it is composed are: (1) a group of Archæan granites and granitic gneisses, traversed in places by numerous quartz-dykes varying in thickness from $3\frac{1}{4}$ to nearly 10 feet, and apparently interbanded conformably with the granites, etc.; (2) the coal-bearing series, resting upon the Archæan rocks—an alternation of thinly-bedded, crumbly, dark-grey, bluish and greenish slates and shales, medium and fine-grained quartzose and felspathic sandstones, and variegated marls; and (3) the neo-volcanic eruptive rocks, among which widespread basalt-flows, of palpably much later date than the coal-bearing beds, form a conspicuous feature. So far, two seams of real industrial importance have been proved in the coal-measures: the upper, or Lokhutai seam, attains thicknesses varying from $19\frac{1}{2}$ to 28 feet, and has a roof of slate; the lower, or Alexander seam, varies in maximum thickness from $55\frac{3}{4}$ to $62\frac{1}{4}$ feet, and has a roof of sandstone. But, in the Tshentsintai mines, west of the Yanbaipu, a continuation of the Lokhutai seam is worked, which exceeds 118 feet in thickness. Both seams strike conformably with the measures among which they occur, east and west, and dip almost due north at an angle of 40 degrees. The actual vertical distance between the two seams has not yet been ascertained, nor has their possible further extension eastward and westward been determined. The coal lights easily, is non-caking, and makes a fair amount of ash. The mineral itself and the contiguous shales and sandstones are filled with yellow amber-like inclusions, varying in size from a peppercorn to a pea.

The plants described appear to be of Oligocene age, including such ferns as *Aspidium* and *Osmunda*, conifers such as *Glyptostrobus* and *Sequoia*, also remains of poplar, beech, walnut, etc. The flora coincides very closely with those of other Tertiary formations elsewhere in Manchuria, in the Amur region, and in the island of Sakhalin, Fushun being so far the southernmost locality on the mainland of Eastern Asia where Oligocene plant-remains have been proved. It is to be inferred, therefore, that the coal-seams are of Oligocene (Middle Tertiary) age. A further resemblance of this Tertiary flora is noted, with certain fossil floras of Japan and Alaska. L. L. B.

MINERAL RESOURCES OF KOREA.

Ressources minières de la Corée. By — Berteaux. *Annales des Mines, series* 10, *Mémoires*, 1907, *vol. xi., pages* 156-158.

Some doubt is cast by the author on the accuracy of the statistics of mineral output of the Korean Empire, published by the Commercial Depart-

* *Transactions of the Imperial Russian Geographical Society*, 1906, vol. xxxviii., No. 2.

ment of the Japanese Ministry of Foreign Affairs, on the ground that the figures depend largely on the declarations made by interested parties to Customs officials. It is suggested that if the totals published by the Japanese were trebled, they would approximate more closely to the actual totals of output and export.

The most abundant outcrops of auriferous quartz occur in the province of Hpyeng-An; but the gold-placers bulk, perhaps, more largely in the Korean output of the precious metal. Indeed, it is estimated that, at present, two-thirds of the gold known to be produced in the peninsula is got from the placers. Although the demand for silver is considerable, the natives making their jewellery of it exclusively, the metal is not mined in Korea. Silver-ores have been proved to exist, but the conditions of working are too difficult, and native labour too slow and costly, to repay mining these deposits. In the north and in the south of the peninsula, copper occurs abundantly, but rarely in the central districts. The principal copper-mine at present is in the Kap-San district of the northern province of Ham-Kyeng, on the eastern watershed of the peninsula. Iron-ores occur in the Hoang-Hai province and elsewhere, but are not as yet worked to any noteworthy extent.

It does not appear that a very brilliant future lies before the Korean coal-fields. Apart from the Hpyeng-Yang deposits, yielding a light smokeless anthracite, which leaves little ash, the seams which are met with in various provinces yield, despite their occasional great extent, a bituminous coal of poor quality.

Rock-crystal of fine quality is exceptionally abundant in the Kyeng-Tjyon district, province of northern Kyeng-Syang-To. Talc, of excellent quality also, occurs in various localities, but has never been seriously worked.

L. L. B.

COAL-BEARING BEDS IN THE KUZNETSK DISTRICT, SIBERIA.

Description géologique de la Partie Sud-Ouest de la 15ème Feuille de la Carte générale du Gouvernement de Tomsk (Feuille Kouznetsk). *By* B. K. Polienov. *Travaux de la Section géologique du Cabinet de Sa Majesté*, 1907, *vol. vi., pages 275-305 and a map.*

In the western and south-western portions of the district rise the Salair mountains, consisting of highly dislocated Palæozoic rocks; while the rest of the area is an undulating steppe, through which, from north to south, runs the deep-cut valley wherein flow the Kondoma and Tomi rivers. Nearest the central axis of the mountain-range, Lower Devonian metamorphosed slates and marmorized limestones crop out; these are succeeded by Middle Devonian coral- and brachiopod-limestones, with a few sandstones and volcanic tuffs; and these again by Lower Carboniferous limestones. The entire eastern and north-eastern part of the area is occupied by coal-bearing strata, mantled over by drift-deposits.

The Lower Carboniferous, as in all other portions of the Kuznetsk basin, is represented by limestones containing *Spirifer tornacensis* and *Syringothyris cuspidata*, with subordinate sandstones and conglomerates, and corresponds exactly with the Tournaisian of Belgium.

The coal-bearing beds belong chiefly to the lowermost portion of the productive Coal-measures, and consist of arkose-like sandstones, with shales among which coal-seams and thin bands of sphærosiderite are interbedded. These coal-seams are very numerous, and some are of considerable thickness, as for instance, one on the banks of the Tomi which measures more than 21 feet. The quality is variable, but lean coals predominate over the other kinds (gas-coal, etc.).

Iron-ores occur throughout the productive coal-area, either in the form of the thin bands previously mentioned, or in lenticles and concretions. They include brown iron-ores as well as sphærosiderite. L. L. B.

GOLD-BEARING REGIONS OF SIBERIA.

(1) *Carte géologique de la Région Aurifère de la Zéia: Descriptions des Feuilles III. 2 et III. 3. By* E. Ahnert. *Explorations géologiques dans les Régions Aurifères de la Sibéric*, 1904-1906, *pages* 1-304 *and* 1-191, *and* 2 *plates;*

(2) *Région Aurifère de la Léna. By* A. Gerasimoff *and* P. I. Preobrazhensky. *Ibid., livraison iii., pages* 1-43 *and* 45-60, *and* 2 *maps;*

(3) *Région Aurifère de l'Amour. By* E. Ahnert, M. M. Ivanoff, A. Khlaponin, P. Rippas *and* P. Yavorovsky. *Ibid., livraison v., pages* 1-145 *and* 5 *maps: and*

(4) *Carte géologique de la Région Aurifère de l'Amour: Sélimdja, Description de la Feuille I. By* A. Khlaponin. *Ibid., pages* 1-72 *and an index-map.*

The area dealt with in the two memoirs included under (1) extends from 126° 6′ to 127° 6′ longitude east of Greenwich, and from 54° 59′ to 55° 20′ latitude north. It is watered by three streams (the Unakha, the Olongro, and the Dess) belonging to the Brianta river-basin, and by some still smaller streams belonging to the Ghilui river-basin. The country is undulating, and is traversed near the western limit of the area described, from north to south by a mountain-range. Along the Unakha and the Dess and in their vicinity, high scarps, wild ravines, and tumbling rapids attest the rugged character of the surface-relief in the western portion of the area. There are, too, marked belts of depression; and, although the main physiographical features are undoubtedly the result of atmospheric and aqueous erosion, tectonic agencies have also played their part in originating those features. The predominant rocks are of granitic type, including grey plagioclase-granite (prevalent in the eastern and less rugged portions of the area) and pale biotite-granite; also plagioclase- and quartz-porphyries, kersantites of extremely varied composition, trachyte-andesites, dioritic dykes, and a little peridotite. The gneisses occur in great variety, including granitic and pegmatitic gneisses, at least two biotite-gneisses, hornblende-gneisses, etc. The gneissic rocks are of typically secondary formation, some of them evidently originating from massive crystalline rocks which had undergone the complicated process of multiple injection of eruptives along joint-planes and cleavage-planes, coupled with recrystallization of their minerals under the influence of partial solution and great pressure.

The sole undoubted sedimentary deposits in the area are of the nature of rubble resulting from the superficial weathering of the rocks just described, drift, and alluvia; the hill-slopes are mantled by forest-humus or *tundra*, the maximum thickness of which is usually dependent on the depth of the perpetually frozen ground (20 to 40 inches, according to local circumstances). Gold-bearing solid rocks have been sought for in vain, although clandestine washings are occasionally conducted in the sands of the river-bed of the Dess. The author himself found traces of gold on experimenting with some sands in the gorge of that river; but the alluvia of the Olongro and the Unakha are barren. Quartz-veins of any consequence have not so far been observed in the scarps abutting on all these valleys. Chemical analyses have failed to yield traces of gold in any rocks from the district, except the hornblende-gneiss and spidotic mica-gneiss, and the porphyrite, all from the Dess valley. The singular absence of pyrites in all these rocks is noticed, with the sole exception of the Unakha granites.

The investigations of Mr. A. Gerasimoff were continued in 1902 in the Olekma division of the Lena region, a rugged country made up of metamorphic rocks (schists, phyllites, grits, and quartzites) and sedimentaries (limestones, dolomites, mottled gypsiferous clays, etc.) of probably Cambrian age. Recent alluvia are found only along the Lena, and the gold-mining industry is of scant importance. The Mikhailo-Ivanovsky workings in the Vacha basin are no better organized than the chance diggings of clandestine prowlers after gold, and yield barely 650 grains of the precious metal per ton of material. The Spektralny mine, worked both opencast and by underground galleries, yields 1,234 to 1,390 grains of gold per ton of material. The Voskressensky placer is exhausted.

Mr. Preobrazhensky explored the Takhtyga and Anangra river-basins, immediately to the west of the region just described. It is an extremely rugged country, the valleys being oriented in every possible direction, in disregard of the strike of the rocks. These valleys are in the form of broad marshy troughs in their upper portions, narrow (though occasionally widening into lakes) in their lower portions. One half of the area is taken up by granites, the other half by schistose metamorphic rocks. Gold certainly occurs in the alluvial deposits—there are, however, few outcrops of these, and they have not been minutely studied as yet. In the two river-basins there are in all five placer-workings, and those not very actively worked. The gold is distributed so irregularly in the sands, which are themselves so inconstant, that the district has acquired an unfavourable reputation from the point of view of the gold-mining industry—the more so that exploration-work had been of a very inadequate description. However, the barren cover is of no excessive thickness (from 13 to 33 feet), and all the geological data concur in assigning to the sands a sufficient quantity of the precious mineral to justify mining operations which would most probably be remunerative.

Turning now to the Amur region, we find in Mr. Ahnert's description of his traverses of the Stanovoi mountain-range and of the Zeia and Aldan basins between which it forms the water-parting, that in 1902 four placers were being worked in the so-called "Aldan gold-belt," and that requests for concessions had been put before the Government authorities to work every watercourse in that area down to the smallest streamlet. But little exploration-work had been done, except in the case of the placers just mentioned. The amount of gold in these placers depends directly on the nature of the rock which forms the subsoil in the respective localities. There is reason to believe that in no case has the gold been transported by water for any considerable distance.

Researches in the region of the Amgûn (a left-bank tributary of the Amur) tend to show that along its lower course the presence of gold is in some way connected with the crystalline schists; while along the Kolchan (a tributary of the Kol which flows into the Sea of Okhotsk), the precious metal appears to be connected with the most recent eruptive rocks, especially the liparites.

The gold-bearing portion of the Little Khingan district is made up almost entirely of gneisses and granites and crystalline schists, the geological conditions being much the same as in other gneisso-granitic regions of the Amur basin. The primary matrix of the gold appears to be predominantly the dark gneiss, and also the dyke-rocks of the granitic group (pegmatite and tourmaline-granite). Segregations of hornblende are good indicators, while the quartz-veins which occasionally seam the gneisses are comparatively poor in gold. All the placers in the area here described are of post-Pliocene age, except the Nagorny placer, which lies 260 feet and more above the level

of the Sutar river. Here, the sands, resting upon a bed-rock of fine-grained granite, include an auriferous layer from 30 inches to 16½ feet thick, the more or less barren "cover" varying in thickness from 33 to 100 feet: at many horizons of this "cover," as much as 15½ grains of gold per ton can be got. The auriferous layer proper yields anything between 30 and 355 grains per ton, the average yield of that portion of the placer which was being worked in 1901 exceeding 46 grains per ton. The post-Pliocene sands, whether *in situ* or redeposited (*remaniés*), are hardly conspicuous for their wealth in gold, the normal tenour not exceeding 38½ to 115¾ grains per ton; although the yield occasionally reaches a maximum of 185 grains per ton.

In the Jalinda region west of the Amur, gold-quartz veins undoubtedly exist; but no practical results have yet been achieved in regard to them, and the alluvial gold alone is worked. The placers are irregularly dispersed over the entire area, in groups of small extent; some of them are undoubtedly derived from the dyke-rocks (pegmatites and aplites), others from the belt of contact-metamorphism at the junction of the sedimentaries and the gneisso-granitic rocks, while others again are genetically associated with pale quartzose conglomerates and grits.

Mr. A. Khlaponin, in describing the geology of the Selemja region, assigns the primary origin of the gold in the placers to the metamorphosed rocks, and points out that, more especially in the western portion where the effects of dislocation and erosion have assumed greatest intensity, the prospector may expect to find auriferous sands rich enough to repay working.

(5) *Die Goldseifen des Amgun-Gebietes (Ostsibirische Küstenprovinz).* *By* ERNST MAIER. *Zeitschrift für praktische Geologie*, 1906, *vol. xiv., pages* 101-129, *with* 11 *figures in the text.*

In the great belt of auriferous deposits which stretches all across eastern Siberia from Transbaikalia onwards, those which lie farthest east and are of most recent origin belong to the gold-placer group of the Amgun river. The district is topographically defined on the east by the vast depression extending northward from Khabarovsk through the region of the big lakes (Ovoron, Chikchagir, etc.), and on the west by the mountain-range of the Little Khingan. The Amgun itself is a left-bank tributary, some 500 miles in length, of the great river Amur, into which it debouches about 50 miles above Nikolayevsk. In its middle course it flows through the great lacustrine plain, while its more important left-bank tributaries (among them, the Kerbi and the Nilan) take their rise in the northern spurs of the Little Khingan. It is more particularly in the area defined by the Kerbi and the Nilan that the gold-placers presently to be described are situated. The Little Khingan extends through seven degrees of latitude north-eastward to the Sea of Okhotsk, and is built up of a great variety of rocks, among which the eruptives are chiefly represented by a granite-porphyry forming the crest of the mountains, from altitudes of 3,500 to 4,000 feet or so, while some peaks rise to a height of 6,400 feet. From its eastern base, the gold-placer district proper stretches eastward, in the form of a well-wooded undulating country, which has rather the character of a succession of foot-hills descending evenly to the Amgun-Amur plain. The Kerbi and the Nilan, already mentioned, are distinguished by their length, and by the volume and lithology of their alluvial deposits, from all other rivers in that region: they alone carry granitic débris, while the rivers which intervene between them have perforce confined their erosive activity to areas of crystalline schists and phyllites. It is true that north of the lower course of the Kerbi, a granitic outcrop occurs which is the sole auriferous deposit that cannot be traced to the phyllites.

South-east of the auriferous district great masses of granitic rocks apparently occur between the upper course of the Amgun and the Amur, and it would seem that we are dealing with an area of gold-bearing slates ringed round by granite. Quartz is of widespread occurrence, and is seen in the few available natural exposures to take the form of lenticles and nests; consequently, it furnishes much of the material of the alluvial deposits. Pyrites is also a very commonly-occurring mineral in the slates.

The working of the gold-placers was started in 1882 in the upper valley of the Sulaki, a right-bank tributary of the Kerbi; but the industry only began to attain real importance in the early nineties, on the discovery of the placers along the Semi and Sulatkitkan rivers, which have since then furnished by far the largest portion of the entire gold-output of the region. The official statistics put the production of the Amgun district for the period 1891-1904 as totalling 739,450 ounces troy, but to this should be added the considerable percentage stolen by the workpeople. The stolen gold was mostly squandered on smuggled spirituous liquors (a strictly forbidden traffic), and by secret and devious routes found its way into China. But, of late years, the Russian Government have put an end to the temptation to smuggle by proclaiming free trade in gold; and the most important mining company in the district having largely replaced manual labour by excavating machinery, the secret pilfering of the precious metal has become exceedingly difficult.

The author appends a map showing the distribution of the workable placers, but refrains from indicating those which are still merely in the prospecting stage. He finds himself able to state, however, that there is little hope of discovering in the district any more placers as rich as those of the Semi and the Sulatkitkan. Apart from the centre formed by these two rivers, the distribution of the workable placers is irregular in the extreme; but traces of gold are everywhere discernible in the alluvial deposits of every valley in the district without exception. One rule, however, can be stated in regard to the workable placers: they are not known to occur in valleys where the stream has a greater fall than 4 per cent., and the most considerable auriferous deposits are found in valleys where the fall ranges from 1 to as little as 0·5 per cent. The valleys are almost invariably asymmetrical, one side being much steeper than the other; and the breadth of the thalweg is generally considerable, an indication of extraordinarily active erosion. An essential characteristic of the alluvial deposits is, that the material of which they are composed is identical with that of the bed-rock and of the rocks now cropping out in the hillsides. Hence the primary source of the gold that occurs in the placers may be looked for in those very rocks.

A detailed description (with map and sections) is given of the placers of the Semi valley and its tributaries, the workable deposits extending over a total length of 12½ miles or more, while the breadth is found to increase progressively as one goes down stream. The climatic conditions recall those of the Klondyke region, but there is at present no adequate evidence of a former complete glaciation of the district. The most important auriferous horizons in the placers are the weathered surface-débris of the phyllites (not immediately above the bed-rock) and the overlying lowermost gravels; but gold does occur more or less abundantly at every horizon, diminishing from bottom to top, with the above-mentioned reservation. A certain amount of gold occurs, occasionally in rich nests, among the bedding-planes of the bed-rock itself, but so irregularly that the working of it is generally leased out to Chinamen and Koreans, whose primitive methods of mining can alone make the stuff payable. An indicator of the presence of gold in the alluvia, etc.,

in fact, the sole visible indicator, is the peculiar clayey "cement" known to the Russians as *primazka*, which coats the pebbles and rock-débris, fills up depressions and fissures, and often forms the binding-material of the detrital deposits. But, although the gold practically never occurs without the *primazka*, the latter is sometimes found without any gold. An elaborate table is given exemplifying the vertical distribution of the precious metal; and the erosion of the Semi valley, as also the accumulation of its gold-bearing alluvia, is attributed solely to the agency of running water. The author states that practically all the placers of the Amgun district are similar in character and origin to those of the Semi; the material of which they are built up is exclusively derived from the phyllites and the crystalline schists. The exception already hinted at, in the case of the Kerbi and Nilan rivers, must, however, be borne in mind: here the alluvia of more recent date are formed of granitic débris derived from the granite-ridges of the Little Khingan. Little exploration-work having been so far accomplished along the Nilan, the author is perforce restricted to a description of the Kerbi placers. Now, although the Kerbi flows for many a mile through a region of slates and schists, and only its headwaters are in the granitic area, the mountains slope so abruptly, the rains are so heavy, and the variations of temperature so enormous, as to intensify erosion to such an extent that the granitic material plays the most important part in the detrital deposits along the entire course of the river. Nevertheless, the gold which occurs in the Kerbi placers is in every respect similar to that of the Semi, and is evidently derived from the schist-and-slate complex. The Yassnyi placer alone, on a tributary which runs into the Kerbi from the north, contains gold derived from the granites, easily distinguishable from the slate-derived gold by its fine even granularity and its crystalline form. A series of great terraces of older alluvium marks out in some places the ancient course of the Kerbi, and in these also gold occurs. The probable history of the formation of the placers is sketched out, and some typical examples are described.

As to the quantity of gold which they contain, this is variable in the extreme, ranging from mere traces to an ounce, or occasionally over 3 ounces troy per metric ton. The average output per ton washed has diminished of late years, but this is (to a great extent) attributable to the fact that, by the modern methods of mining now in vogue in the Amgun district, the poorer stuff is washed as well as the richer. The total output is therefore increased, although the averages have decreased. The workability of a placer hereabouts does not, moreover, depend so much on its absolute wealth, as on the relative thickness of the barren "cover." The gold of the upper tributaries of the Kerbi (Sulaki) and the Nilan (Sivak) is characterized by its coarseness of grain; nuggets weighing from 15 to 150 grains (1 to 10 grammes) are common in all the placers, and some weighing from $\frac{1}{3}$ to 2 ounces (10 to 60 grammes) are occasionally found, but in certain placers only. Once a nugget weighing over 25½ ounces was discovered. The precious metal is generally irregular in form, but in several placers crystals that have undergone very little water-rolling occur, and larger fragments are made up of crystals, or exhibit a symmetrical structure reminiscent of skeleton-crystals. Quartz is frequently associated with the gold, and other mineral-associates are pyrites, magnetite, specular iron-ore, brown hæmatite (forming a film on the gold-flakes), stibnite, and very rarely garnet. In regard to its chemical composition, the gold varies from 910 to 952 fine, the impurities consisting chiefly of silver with a little copper.

The evidence is detailed, by which the author is led to the conclusion

that the entire complex of phyllites and metamorphic schists of the Amgun district, together with the quartz and pyrites which they contain, forms the primary matrix or mother-rock of the gold. Whatever chemical processes may have taken place within that matrix before its erosion, it is certain that, dating from the erosion, the formation of the placers was originated by purely mechanical processes.

The eternally frozen layer in the subsoil of the district (below the 5 feet or so of surface-soil which freezes hard every winter and thaws again in the summer) is of curiously irregular distribution, and does not seem to affect one way or the other the general regularity of the placers. L. L. B.

MINERAL RESOURCES OF THE CHUKCHEN PENINSULA, EASTERN SIBERIA.

Tschuktschenhalbinsel (Ostasien). *By* J. Korsuchin. *Zeitschrift für praktische Geologie*, 1906, *vol. xiv., pages* 377-382, *with* 2 *maps in the text.*

When the world-renowned gold-placers at Cape Nome, on the Seward peninsula, were discovered in 1899, it occurred to certain enterprising Russians that there was a possibility of finding similar wealth in the soil of the Chukchen peninsula, which faces Cape Nome on the opposite side of Bering Straits. The exclusive right to search for gold and other useful minerals over the entire peninsula, in other words, over an area of 38,601 square miles, was conceded to Mr. W. von Wonliarliarsky, who thereupon sent out several exploring expeditions in succession to that remote region. The author was the leader of the expedition that went out in the year 1903, since when (he believes) no further investigations have been carried out in the Chukchen peninsula. Although it had been discovered as long ago as 1648, the interior of the country remained practically unknown as late as the year 1900, when Prof. Bogdanovich led thither the first Wonliarliarsky expedition. During the short Arctic summer the professor devoted his attention to the geological survey of the coast, but scientific work was much hindered, and finally stopped, by the bickerings which arose among the members of the expedition. A synopsis is given of such petrographical and geological data as, under these difficulties, Prof. Bogdanovich was able to accumulate.

In Abolesheff Bay, he found lodes of pyrites traversing felsite-porphyries, and that the shores of Providence or Plover Bay consist exclusively of crystalline igneous rocks, among which biotite-granite plays the chief part. Limestones, mica-schists, calc-schists, and talcose schists occur between Cape Pageliau and Koniam Bay, on the northern shore of which they are overlain by eruptive rocks, chiefly granites and porphyries; fine-grained, pale-grey sandstones were observed in Mechigmen Bay, and the headland of Cape Dezhneff, which juts out into Bering Straits, is built up in part of limestone and in part of hornblende-granite.

In the beginning of July, 1903, the steamer carrying the expedition under the author's command, dropped anchor in Lawrence Bay, in the north-eastern portion of the Chukchen peninsula, 21 days after leaving Vladivostok. On the shores of the above-mentioned bay is a trading-station belonging to the company founded by Mr. W. von Wonliarliarsky. The author utilized the week during which the expedition was inevitably delayed there to examine the north-western coast, where it was reported that, shortly before his arrival, certain American prospectors had struck auriferous deposits. This statement, however, appears open to doubt, as the so-called ore-deposits proved to be very irregular aggregates of quartz containing chalcopyrite and iron-

pyrites, at the contact of hornblende-granite with limestone. No means on the spot for assaying the quartz being available, the author took hand-samples away with him; but these were lost when the steamer was wrecked, on the return journey, on the coast of northern Japan.

The peninsula is bare of woodlands or even of bush, and thus expeditions are obliged to carry their fuel with them, in the shape of petroleum. Despite these and many other difficulties, the author contrived to plot out a geological map of the north-eastern portion of the peninsula, the largest areas of which are covered by granites and gneisses; there are also patches of limestone and some clay-slates. The importance of examining carefully the last-named lay therein, that the occurrence of gold in the Seward peninsula, on the American side of the Straits, is connected with the metamorphosed clay-slates or shales. The author reports, in regard to the clay-slates which he found along the course of the Kolöl river, that they are highly contorted and, so to say, intergrown with ice, which never thaws at any season: they are overlain by a few feet of loamy rubble, and seamed with vennles of quartz. At one locality only were signs apparent of a quartz-vein of any notable thickness, and this does seem to be auriferous. Otherwise, the author saw but very slight traces of gold in the clay-slate area.

South-west of Cape Dezhneff, there is a gold-placer on the Thunilthan, not far from the trading-station at the mouth of that river. The bed-rock is a highly-contorted, much metamorphosed clay-slate which almost passes into mica-schist, and is traversed by a multitude of quartz-vennles. The placer only yields about 7 grains of gold per ton, and is consequently of no industrial importance.

The author discovered a graphite-deposit on the flanks of the Telgakar hill, near the headwaters of the river of the same name. The mineral is of extraordinarily fine quality, and is compared with the very best varieties of Ceylon graphite. It occurs in big lenticles, in a belt of graphitic gneiss striking north-westward and dipping almost at right-angles. The author traced this belt for a distance of $1\frac{1}{4}$ miles; he estimates its thickness as being at the very least 70 to 100 feet; and reckons the average percentage of graphite in the gneiss as ranging from 15 to 20 per cent. Not far from this graphite-deposit, the author came upon a large patch of ground covered with lumps of brown hæmatite, which would seem to indicate the occurrence of a deposit of iron-ore; but he was deprived of the opportunity of looking further into the matter.

The author is inclined to correlate the rocks of the entire south-eastern coast of the Chukchen peninsula with the oldest rocks of the Seward peninsula, classified by the American geologists as the Kiglnaik Group. This being granted, Bering Straits would represent a sunken syncline intervening between the second anticline of the Seward peninsula and a third anticline on the Chukchen peninsula, and there are reasons for believing that the separation of the two peninsulas by the sea took place in late Pleistocene times. The conclusion is reached that the recurrence of the industrially valuable gold-bearing rocks of the Nome Group must be looked for in the direction of Kolintshin Bay and Anadyr Bay on the coasts of the Chukchen peninsula. It is noticeable that on the Seward peninsula, all the deep indentations of the coast, such as Norton Bay, Port Clarence, Eschscholtz Bay, etc., coincide with the development of this Nome Group. L. L. B.

COPPER, TIN AND GOLD IN KATANGA, CONGO FREE STATE.

(1) *Les Gisements de Cuivre du Katanga.* *By* H. Buttgenbach. *Annales de la Société géologique de Belgique*, 1905, *vol. xxxi., Mémoires, pages* 515-564, *with* 10 *figures in the text and* 1 *plate.*

The Katanga district, properly so-called, lies in the extreme south-east of the Congo State, between the tenth degree of latitude south and the water-parting of the Congo and Zambesi river-basins. It had long been known as the source whence the natives of the neighbouring regions derived the copper from which they made their implements and utensils, and was traversed by various explorers in the latter half of the nineteenth century. It was not, however, until 1885 that a European actually examined one of the cupriferous deposits. In 1902, the author was commissioned to carry out investigations in the district, by a Belgian company which was working in agreement with the Tanganyika Concessions, Limited, and the result of 18 months' prospecting-work more than confirmed all the expectations that had been formed. In a word, the Katanga district may be regarded as one of the richest (if not itself the richest) copper-ore fields in the whole world. And yet exploration-work was not pushed to a vertical depth greater than 130 feet or so, because the ore-deposits proved to be so numerous and so extensive that (for the purpose in view) it was not considered needful to do so. The deposits are very similar in character, and a detailed description of each one would involve a monotonous repetition, varied only by statistics as to area, etc.

The country, as a whole, is a vast undulating tableland, comparable in some respects with the plateau of the Ardennes, varying in altitude from 4,300 to 4,600 feet, but with some elevations going up to 5,300 feet. The rivers, which have, in a few cases, cut very deep gorges in this peneplain, are divisible into two main systems: (1) the south-to-north flowing rivers, including the Lufira, the Lualaba, and their principal tributaries; and (2) the lesser tributaries of the foregoing, which flow in a direction sensibly at right-angles to that above-mentioned. No eruptive or granitic rocks occur within the mining district itself; the strata are all sedimentary, sometimes intensely metamorphosed, and generally dipping at an angle higher than 45 degrees. Towards the north these beds are overlain by practically horizontal grits, which are possibly of lacustrine origin. In the mining district, the Kazembe and Kafunda-Mikopo systems of Prof. J. Cornet (Upper Devonian and doubtfully Carboniferous) are chiefly represented, the predominant rocks being the Upper Kazembe violet schists. The author indicates on his map no less than sixty-six distinct cupriferous deposits, but there are many other localities where strata impregnated with malachite are known to crop out. The ore-deposits almost invariably occur on the slopes, or on the brows, of more or less isolated eminences, the barren aspect of which contrasts vividly with the luxuriant forest amid which they uplift their crests. The copper-salts with which the soil of these hills is saturated probably account for their sterility. The ore (malachite and chrysocolla) appears to have been precipitated amid all the fissures and interstices of the strata by metalliferous solutions which percolated through them. The bands of malachite, even at Kakanda, whence show-specimens are obtained, hardly ever exceed 2 inches in thickness. The malachite is frequently mammillated, and, in such cases, alternates with chrysocolla. The average results of assays of ores selected from ten different deposits show a percentage of 14·21 of metallic copper. Gold and silver are always present in varying proportions, as is proved by the analysis of more than 150 samples: in some cases the amount of gold exceeds 45 grains per

ton, and that of silver 2½ ounces troy. Pulverulent black oxide of copper, intermixed with oxides of iron and manganese, is not of uncommon occurrence in the Katanga deposits, and is probably derived from the decomposition of other minerals. Chalcopyrite and cuprite are seldom met with; native copper has been found, in rounded grains, among the alluvia, part of which is formed by the tailings washed down from the upper portion of the Kambove deposit.

For description, the author selects those deposits which appear to him to be of the greatest importance or interest. So he describes the Likasi, Fungurume, Luushia, Kolwezi, and Kambove deposits in some detail. The last-named deposit has been the object of a good deal of exploration-work, but the shafts have hardly been pushed deep enough to furnish an adequate idea of the enormous industrial importance which the workings are eventually destined to assume. On the whole, the author is inclined to think that these carbonated ores are merely the oxidized gossan of deeper-lying sulphidic ores, which latter possibly are interbedded with strata of the same age as those among which the former occur. The wealth of these gossans may be gauged by his estimate that, in nine localities alone, 1,200,000 tons of copper could be extracted from them.

(2) *La Cassitérite du Katanga.* *By* H. Buttgenbach. *Annales de la Société géologique de Belgique*, 1906, *vol. xxxiii., Mémoires, pages* 49-52, *with* 2 *figures in the text.*

Within the last year, a belt of stanniferous deposits of considerable importance has been traced in Katanga, ranging parallel with the Upemba *graben* (or fault-valley) and its thermal springs, and to the eastward of it. These deposits would appear to have been formed during that period of tectonic dislocation which determined the course taken by the Lualaba river as it issues from the gorges of Zilo, especially after its confluence with the Lufupa. The author has in preparation a geological account of the entire region, the future industrial prosperity of which is undoubted; meanwhile, in connexion with the description of sundry specimens of cassiterite brought from there, he draws attention to the massif of pegmatoid granite, a comparatively narrow belt of highland, but extending over a distance approaching 100 miles north-eastward from the above-mentioned confluences of the Lualaba and the Lufupa. On the western flank of this massif tourmaline-quartzites, mica-schists, etc., crop out, and it is at the contact of these rocks (more especially the quartzites) with the granite that the tinstone occurs in practically vertical lodes. It is to the south of this district, upstream from the Zilo rapids, that the cupriferous deposits occur, as also the auriferous deposit of Ruwe, on the north-western margin of the Kazembe plain. The Zilo rapids, which carry the level of the Lualaba more than 1,300 feet down in the distance of 31 miles, rush tumultuously over a succession of quartzites, schists, grits, and slates, invaded in places by eruptive rocks.

The stanniferous area is very rugged, seamed by ravines wherein the lodes occasionally crop out. Usually, however, the lodes are masked by gravelly débris of the subsoil, including pebbles of all dimensions, as well as nodules of tinstone varying in weight from less than an ounce to several pounds. These placer or gossan-deposits are not seldom of greater industrial value than the lodes themselves.

Geologically speaking, the Katanga stanniferous deposits differ in nowise from those of other regions. In the lodes the cassiterite forms in conjunction with quartz a rock of coarse structure, often cemented by white mica. The

quartz appears to have moulded itself on the cassiterite. The "nodules" of the ore in the soil-débris are generally broken, but they still retain roughly the external form of the original crystals. They present this peculiarity, that the faces of the pyramid, which generally surmounts the quadratic prism of the mineral, are conspicuous both for size and frequent occurrence, and seem to have resisted best the agents of disintegration.

(3) *Quelques Faits à propos de la Formation des Pépites d'Or: Les venues métallifères du Katanga.* By H. Buttgenbach. *Annales de la Société géologique de Belgique*, 1906, *vol. xxxiii., Mémoires, pages* 53-70, *with* 5 *figures in the text.*

This memoir is largely based on the investigations which the author has conducted within the past few years in the Katanga district of the Congo Free State. Premising that in Venezuela, according to Prof. A. de Lapparent, the deposits of native gold are probably the ferruginous gossans of lodes of auriferous pyrites; and further, that the size of the nuggets in the Californian gold-placers irresistibly impels the inference that the former outcrops of the lodes, long ago swept away by erosive agencies, were by far richer in gold than the deeper-lying portions, the author proceeds to show how the argument is clinched by the evidence collected in Katanga. There is reason to believe that the nuggets actually increased in size while the gossans were in process of denudation, and while the placers were in process of formation; nor was this growth otherwise than fairly rapid. A sketch-map shows how widespread is the occurrence of gold in the river-sands of Katanga, and how widespread also are the cupriferous deposits, in which gold almost invariably occurs, though in small proportion.

The only important placers thus far investigated are those of Ruwe and Kambove, especially the former. At Kambove it is noticeable (1) that in the ravines, the heads of which lie in a direction opposite to that of the cupriferous deposits, no gold is to be found; (2) that in the Livingstone ravine, where auriferous gravels, extending over a length of 2 miles or more, are worked, no gold occurs up stream of the cupriferous deposit; (3) that outside the ravines, gold is only found on the plateau down stream of the cupriferous deposit and drained by the ravines; (4) that the biggest nuggets occur in the Livingstone ravine, which cuts clean across the cupriferous belt; and (5) that when the gravel is washed in the pan, the quantity of gold obtained is proportional to the abundance of grains of malachite and hæmatite which make their appearance a little before the end of the operation. Now, as, on analysis, the cupriferous grits and shales of Kambove invariably reveal the presence of gold—sometimes as a mere trace, sometimes in such proportions as 15, 30, or 45 grains per ton—it is plain that the placer-gold is derived from those rocks. On the other hand, as the precious metal never occurs in them in the visible shape of nuggets or flakes, it is equally plain that such nuggets or flakes (now found in the placers) must have been formed during the denudation of the former outcrops of the cupriferous deposits. This secondary concentration of gold often takes place (in the tropical regions to which the author refers) with considerable rapidity, and in this connection he cites some almost incredible instances from the Likasi and Fungurume deposits—a single shower in each case having sufficed to concentrate in flakes and nuggets the previously invisible gold. It must not be inferred, however, that all the gold found in the streams of the Katanga district is necessarily derived from the cupriferous deposits. The occurrence of gold quartz-reefs, especially in the south-western portion of the district, is, to say the least, extremely probable.

The author then describes an entirely different order of deposit, that of Ruwe, where gold-nuggets have been formed at the expense of the gold contained in infinitesimally minute particles in a sedimentary rock. On the southern flank of a hill ranging north-east and south-west, a series of friable grits crop out beneath the stratum of surface-débris. They dip 30 degrees north-westward, but flatten out in depth. Near the outcrop they carry thin flakes of gold: in depth, impoverishment unto barrenness is rapid, with the exception of one bed, about 8¼ feet thick, which yields a fairly constant assay of: 11 parts of gold, 12 parts of platinum, and 2 parts of palladium per million. The overlying stratum of surface-débris has been methodically worked for more than a year, and yields gold-nuggets varying in weight from 31 to 2,470 grains (2 to 160 grammes), the average weight being from 154 to 925 grains (10 to 60 grammes). Several of these nuggets are figured by the author.

The Ruwe grits are the result of deposition, in the prehistoric Kazembe lake, of the decomposition-products of the belt of ancient rocks which surrounded that lake, while the surface-stratum is in turn the result of the decomposition of the grits. The nuggets in this stratum are undoubtedly derived from the gold contained in the platino-auriferous bed previously described. They never contain platinum or palladium, which would appear to have remained impervious to the chemical changes that reacted on the gold and silver (the average composition of the nuggets is 99·53 per cent. of gold and 0·47 per cent. of silver).

In the course of his memoir, the author inferentially emphasizes more than once the habit to which gold is subject of concentrating on organic nuclei, but he states clearly that the presence of organic matter is by no means a necessary factor in the process of accretion of nuggets. L. L. B.

BAROMETER, THERMOMETER, ETC., READINGS FOR THE YEAR 1906.

By PERCY STRZELECKI.

The barometer, thermometer, etc., readings have been supplied by permission of the authorities of Glasgow and Kew Observatories, and give some idea of the variations of atmospheric temperature and pressure in the intervening districts in which mining operations are chiefly carried on in this country.

The barometer at Kew is 34 feet, and at Glasgow is 180 feet, above sea-level. The barometer readings at Glasgow have been reduced to 32 feet above sea-level, by the addition of 0·150 inch to each reading, and the barometrical readings at both observatories are reduced to 32° Fahr.

The statistics of fatal explosions in collieries are obtained from the annual reports of H.M. Inspectors of Mines, and are also printed upon the diagrams (plates xxviii. and xxix.) recording the meteorological observations.

The times recorded are Greenwich mean time, in which midnight equals 0 or 24 hours.

Table I.—Summary of Explosions of Fire-damp or Coal-dust in the several Mines-inspection Districts during 1906.

Mines-inspection Districts.	Fatal Accidents.			Non-fatal Accidents.	
	No.	Deaths.	Injured.	No.	Injured.
Cardiff	2	8	0	4	5
Durham	2	26	2	4	4
Ireland	0	0	0	0	0
Liverpool	0	0	0	0	0
Manchester	0	0	0	0	0
Midland	1	1	0	12	16
Newcastle-upon-Tyne ...	1	4	1	7	7
Scotland, East	3	3	5	20	22
Do. West	2	3	1	43	57
Southern	0	0	0	3	4
Stafford	2	2	1	4	5
Swansea	4	8	8	24	28
Yorkshire	0	0	0	6	9
Totals	17	55	18	127	157

TABLE II.—LIST OF FATAL EXPLOSIONS OF FIRE-DAMP OR COAL-DUST IN COLLIERIES IN THE SEVERAL MINES-INSPECTION DISTRICTS DURING 1906.

1906.	Colliery.	Mines-inspection District.	Deaths.	No. of Persons Injured.
*Dec. 6, 1905, 7·30	Newbattle	Scotland, East ...	1	3
Jan. 5, 6·15	Prestonlinks	Do. ...	1	0
.. 28, 8·30	Polmaise (No. 2 Pit) ...	Scotland, West ...	2	0
Mar. 22, 8·30	Phœnix Glyncorrwg ..	Swansea	1	1
June 1, 16·0	Court Herbert	Do.	5	4
,, 2, 6·45	Glenboig (fire-clay) ...	Scotland, East ...	1	2
Aug. 8, 14·30	Coneygre (No. 120) ...	Stafford	1	0
,, 18, 12·30	Penygraig	Cardiff	2	0
,, 21, 8·30	Lingdale mine	Durham	1	1
Sept. 1, 8·5	Portland (No. 2 Pit) ...	Midland	1	0
,, 8, 7·30	Glangarnant	Swansea	1	3
.. 24, 13·30	Dumbreck (No. 2 Pit) ...	Scotland, West ...	1	1
Oct. 14, 23·40	Wingate Grange	Durham	25	1
Nov. 10, 15·10	Albion	Cardiff	6	0
.. 18, 12·30	Cefnstylle	Swansea	1	0
.. 12, 10·30	Parkhall	Stafford	1	1
.. 17, 10·35	Urpeth (Busty Pit) ...	Newcastle-upon-Tyne	4	1
			55	18

*Included in list for 1905 amongst non-fatal accidents; the man died, however, early in 1906.

TABLE III.—LIST OF NON-FATAL EXPLOSIONS OF FIRE-DAMP OR COAL-DUST IN COLLIERIES IN THE SEVERAL MINES-INSPECTION DISTRICTS DURING 1906.

1906.	Colliery.	Mines-inspection District.	No. of Persons Injured.
Jan. 2, 15·0 ...	North Walbottle	Newcastle-upon-Tyne	1
,, 5, 0·30..	Phœnix Glyncorrwg ...	Swansea	1
,, 5, 9·30...	Bowhill (No. 2 Pit) ...	Scotland, West ...	2
,, 12, 1·0 ..	Lochwood (No. 3 Pit) ...	Do. ...	2
,, 14, 11·30...	Walkinshaw (No. 2 Pit) ...	Do. ...	1
.. 15, 5·0 ...	Tarbrax (oil-shale) ...	Scotland, East ...	1
,, 15, 13·0 ...	Carnock (No. 2 Pit) ...	Scotland, West ...	1
,, 18, 9·50...	Victoria (No. 1 Pit) ...	Do. ...	1
,, 18, 17·0 ...	Knowle	Stafford	2
,, 18, 20·40..	Newburgh	Newcastle-upon-Tyne	1
.. 19, 7·30...	Phœnix Glyncorrwg ...	Swansea	1
,, 24, 3·0 ...	Blaenavon (Milfraen Pit)...	Southern	2
.. 25, 2·30...	Closyryn	Swansea	1
.. 28, 7·30...	Dumbreck (No. 2 Pit) ...	Scotland, West ...	2
,, 28, 21·30...	Exhall	Midland	1
Feb. 1, 10·30..	Struther (No. 5 Pit) ...	Scotland, West ...	1
,, 6, 8·30...	Manners	Midland	1
,, 8, 8·10...	Hattonrigg (No. 4 Pit) ...	Scotland, West ...	2
,, 10, 8·0 ...	Stanton (Nadins Pit) ...	Midland	1
,, 10, 8·20...	Pye Hill	Do. ...	1
,, 10, 13·0 ...	Pentre	Cardiff	1
.. 12, 15·0 ...	Gartsherrie (Garteloss No. 1 Pit)	Scotland, West ..	1
.. 14, 16·0 ...	Rigfoot	Do. ...	2
,, 17, 8·30...	Roschall (No. 14 Pit)	Do. ...	1

TABLE III.—*Continued.*

1906.	Colliery.	Mines-inspection District.	No. of Persons Injured.
Feb. 19, 12·45...	Cannock Chase	Stafford	1
,, 25, 23·0 ...	Braidhurst	Scotland, East ...	1
Mar. 5, 15·45...	Carmyle (No. 1 Pit) ...	Scotland, West ...	2
,, 8, 15·0 ...	Brook Drift	Swansea	1
,, 12, 14·30...	Cwmllynfell	Do.	1
,, 16, 6·15...	Springhill	Scotland, West ...	1
,, 19, 7·30...	Furnace Blwm	Cardiff	2
,, 19, 15·0 ...	Shawfield	Scotland, East ...	1
,, 24, 6·30...	Parkhead	Do.	1
,, 24, 7·30...	Clynmil	Cardiff	1
,, 28, 19·30...	Raglan	Do.	1
April 1, 9·30...	Shawfield	Scotland, East ...	1
,, 4, 14·30...	Liverton mine	Durham	1
,, 9, 14·30...	Tareni	Swansea	1
,, 13, 7·30...	Glanmwrwg	Do.	1
,, 19, 13·0 ...	Elsecar Main	Yorkshire	2
,, 20, 13·0 ...	Blaenavon (Milfraen Pit)	Southern	1
,, 25, 11·50...	Helm	Yorkshire	1
,, 27, 8·0 ...	Shawfield	Scotland, East ...	1
,, 27, 13·30...	Lanemark (No. 2 Pit) ...	Scotland, West ...	2
May 1, 6·0 ...	Philpstoun (oil-shale) ...	Scotland, East ..	1
,, 1, 7·45...	Cotes Park	Midland	0
,, 4, 12·30..	Motherwell	Scotland, East ...	1
,, 7, 7·30...	Thankerton (No. 6 Pit) ...	Scotland, West ...	1
,, 11, 14·15...	Merthyr Llantwit ...	Swansea	1
,, 16, 4·0 ...	Crigglestone Main ...	Yorkshire	1
,, 22, 7·30...	Prestongrange	Scotland, East ...	1
,, 22, † ...	Morlais	Swansea	1
,, 25, 20·0 ...	Denington	Yorkshire	1
,, 28, 12·15 ..	Victoria (Brunteliffe) ...	Do.	3
June 1, 0·30...	Graig Merthyr	Swansea	1
,, 4, 7·30...	Cynon	Do.	1
,, 8, 9·0 ...	Capringstone (No. 7 Pit)	Scotland, West ...	3
,, 11, 19·0 ...	Polmaise (No. 1 Pit) ...	Do.	1
,, 12, 8·30...	Carmyle	Do.	2
,, 13, 11·30...	Loscoe	Midland	4
,, 13, 17·0 ..	Twechar (No. 1 Pit) ...	Scotland, West ...	1
,, 14, 8·30...	Pilsley (No. 1 Pit) ...	Midland	1
,, 20, 7·45 ..	Onllwyn	Swansea	1
,, 25, 12·30...	Pleasley	Midland	1
,, 27, 4·30 ..	Seaton Delaval	Newcastle-upon-Tyne	1
,, 27, 6·50...	Victoria (No. 1 Pit) ...	Scotland, West ...	1
,, 27, 12·0 ...	Fergushill (No. 28 Pit) ...	Do.	1
July 3, 12·30...	Glynea	Swansea	1
,, 5, 5·0 ...	Mow Cop	Stafford	1
,, 6, 21·0 ...	North Motherwell ...	Scotland, East ...	1
,, 10, 22·0 ...	Do. ...	Do.	1
,, 14, 10·45...	Hazlehead	Yorkshire	1
,, 30, 15·0 ...	Carmyle (No. 1 Pit) ..	Scotland, West ...	1
Aug. 1, 9·0 ...	Blackwell (A Pit) ...	Midland	3
,, 3, 6·0 ...	Hattonrigg (No. 3 Pit) ...	Scotland, West ...	1
,, 3, 10·30...	Holytown (No. 5 Pit) ...	Do.	1
,, 8, 8·30...	Ashington	Newcastle-upon-Tyne	1
,, 8, 15·0 ...	Auchenharvie (No. 5 Pit)	Scotland, West ...	1
,, 10, 7·0 ...	Gateside	Do.	2
,, 13, 7·0 ...	Auchenharvie (No. 1 Pit)	Do.	2
,, 13, 13·30...	Arniston	Scotland, East ...	1
,, 15, 5·20...	Greenhill	Do. ...	1

† No time given.

TABLE III.—*Continued.*

1906.		Colliery.	Mines-inspection District.	No. of Persons Injured.
Aug.	16, 14·0 ..	Bonvilles Court	Swansea	1
,,	20, 7·0 ...	Woodhall	Scotland, West ...	1
,,	27, 15·0 ...	Mynydd Newydd	Swansea	3
,,	31, 7·0 ..	Granville (No. 2 Pit) ...	Midland	0
Sept.	5, 21·0 ...	Throckley (Blucher Pit) ...	Newcastle-upon-Tyne	1
,,	7, 22·0 ...	Portland (No. 2 Pit) ...	Midland	1
,,	11, 8·0 ...	Onllwyn	Swansea	1
,,	11, 11·30...	Gilmilnscroft	Scotland, West ...	1
,,	15, 1·0 ...	Broughton Moor	Newcastle-upon-Tyne	1
,,	17, 6·0 ...	Craiglon	Swansea	1
,,	21, 7·30...	Calderbank	Scotland, West ...	1
,,	29, 2·50...	St. Helens	Durham	1
Oct.	2, 13·30...	Auchincruive (No. 1 Pit)...	Scotland, West ...	1
,,	3, 14·0 ...	International	Swansea	1
,,	3, 20·0 ...	Brook Drift	Do.	1
,,	5, 19·0 ...	Lanemark (Rigfoot) ...	Scotland, West ...	2
,,	11, 5·15...	North Motherwell	Scotland, East ...	1
,,	16, 7·45...	Teversall	Midland	2
,,	16, 14·0 ...	Cawdor	Swansea	1
,,	17, 17·30...	North Motherwell	Scotland, East ...	1
,,	26, 7·30...	Common (No. 11 Pit) ...	Scotland, West ...	1
,,	28, 10·0 ...	Goatfoot	Do.	2
Nov.	2, 7·30...	Mynydd Newydd	Swansea	1
,,	3, 18·0 ...	South Moor (William Pit)	Durham	1
,,	5, 8·30...	Broomrigg (No. 3 Pit) ...	Scotland, West ...	1
,,	8, 6·30...	Prestongrange	Scotland, East ...	1
,,	15, 6·15...	Devon	Do.	1
,,	19, 21·0 ...	Springside (No. 11 Pit) ...	Scotland, West ...	1
,,	24, 16·0 ...	Foxley (No. 4 Pit) ...	Do.	1
,,	28, 7·30...	Gateside	Do.	1
,,	29, 11·0 ...	Dunnikier	Scotland, East ...	1
,,	29, 19·30...	Lower Varteg	Southern	1
Dec.	1, 3·0 ..	Backworth	Newcastle-upon-Tyne	1
,,	3, 4·30...	Darran	Swansea	1
,,	5, 5·30...	Binchester	Durham	1
,,	5, 8·15...	Sandwell Park	Stafford	1
,,	5, 14·30...	Auchenharvie (No. 5 Pit)	Scotland, West ...	1
,,	11, 13·0 ...	Aitkenhead	Do.	1
,,	13, 9·20...	Saline	Scotland, East ...	2
,,	16, 11·30...	Maesymarchog	Swansea	1
,,	17, 3·0 ...	Morlais	Do.	3
,,	17, 18·0 ...	Polmaise (No. 1 Pit) ...	Scotland, West ...	1
,,	22, 12·30...	Kenmuirhill (No. 2 Pit) ...	Do.	1
,,	24, 6·30...	Carriden	Scotland, East ...	2
,,	24, 15·0 ...	Govan (No. 6 Pit) ...	Scotland, West ...	1
				157

TABLE IV.—BAROMETER, THERMOMETER, ETC., READINGS, 1906.

JANUARY, 1906.

KEW.								GLASGOW.							
	BAROMETER.				TEMPERATURE.				BAROMETER.				TEMPERATURE.		
Date.	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Max	Min.	Direction of wind at noon.	Date.	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Max	Min.	Direction of wind at noon.
1	29·953	29·896	29·842	29·827	38·5	29·5	E	1	29·866	29·860	29·762	29·705	36·9	30·4	NE
2	29·796	29·774	29·666	29·589	44·4	38·7	SE	2	29·586	29·506	29·514	29·461	44·4	35·8	SE
3	29·495	29·497	29·552	29·615	50·1	38·7	SE	3	29·391	29·382	29·364	29·427	43·0	39·8	ENE
4	29·620	29·625	29·667	29·572	51·5	46·6	S	4	29·427	29·475	29·470	29·474	46·8	39·9	SE
5	29·693	29·765	29·869	29·883	51·5	46·9	W	5	29·510	29·604	29·644	29·578	44·9	40·3	W
6	29·422	29·268	29·373	29·593	52·1	43·4	WSW	6	29·338	29·266	29·341	29·487	43·8	38·2	NW
7	29·699	29·687	29·490	29·160	46·0	37·9	WSW	7	29·491	29·444	29·275	29·163	42·7	37·4	SW
8	29·155	29·248	29·438	29·627	47·3	38·6	WNW	8	29·129	29·211	29·298	29·382	40·1	36·5	E
9	29·656	29·464	29·338	29·423	51·2	36·7	SSW	9	29·263	28·954	28·804	28·848	45·2	37·8	SSW
10	29·455	29·553	29·695	29·911	45·2	35·9	W	10	29·022	29·212	29·460	29·673	42·9	37·7	W
11	30·078	30·176	30·115	29·946	46·0	32·0	WSW	11	29·768	29·753	29·486	29·306	45·0	36·6	SW
12	29·802	29·906	29·892	29·711	50·7	45·2	SW	12	29·406	29·473	29·466	29·405	42·3	38·2	SW
13	29·585	29·646	29·778	29·825	52·0	39·0	W	13	29·322	29·337	29·367	29·449	40·7	36·0	SW
14	29·990	30·130	30·125	30·079	48·7	36·0	SW	14	29·571	29·631	29·516	29·377	48·1	36·8	SW
15	30·005	29·920	29·742	29·700	47·0	42·0	S	15	29·256	29·314	29·300	29·312	48·2	38·2	S
16	29·807	29·909	29·781	29·664	48·6	37·9	SW	16	29·364	29·349	29·247	29·239	40·2	34·8	SW
17	29·735	29·948	30·039	30·035	46·8	40·4	W	17	29·328	29·481	29·609	29·629	42·6	34·3	W
18	29·885	29·539	29·354	29·623	49·4	39·7	SW	18	29·513	29·389	29·456	29·615	39·9	36·3	NNW
19	29·826	30·070	30·224	30·414	43·3	35·9	N	19	29·868	30·265	30·334	30·414	40·7	34·2	NW
20	30·520	30·567	30·481	30·265	40·3	30·3	W	20	30·365	30·249	29·986	29·960	47·0	34·0	SW
21	30·048	30·053	30·114	30·288	45·3	40·1	N	21	30·022	30·255	30·379	30·479	46·2	37·8	NE
22	30·410	30·487	30·503	30·570	40·3	33·3	N	22	30·498	30·518	30·501	30·509	39·1	31·1	NNE
23	30·604	30·663	30·633	30·621	35·1	27·0	SE	23	30·474	30·437	30·361	30·305	42·1	37·6	SW
24	30·574	30·517	30·361	30·199	39·8	30·1	S	24	30·208	30·039	29·688	29·516	47·0	40·8	SW
25	29·969	29·763	29·763	29·832	49·2	39·8	W	25	29·516	29·535	29·566	29·542	45·7	38·5	W
26	29·846	29·945	29·997	30·046	52·7	40·0	WSW	26	29·590	29·722	29·703	29·683	50·2	45·1	WSW
27	30·059	30·155	30·171	30·183	51·4	44·8	WSW	27	29·655	29·752	29·770	29·718	50·4	45·6	W
28	30·152	30·146	30·149	30·159	50·1	46·6	WSW	28	29·648	29·720	29·774	29·772	48·8	43·4	WSW
29	30·102	30·100	30·099	30·220	51·9	40·4	SW	29	29·720	29·882	29·949	30·024	44·1	38·8	W
30	30·298	30·373	30·335	30·341	48·1	34·8	W	30	30·064	30·094	30·153	30·234	46·0	39·0	W
31	30·352	30·413	30·392	30·349	46·3	34·3	W	31	30·223	30·179	30·034	30·039	48·1	40·1	SW

FEBRUARY, 1906.

1	30·279	30·239	30·217	30·242	47·1	40·4	WSW	1	30·038	29·997	29·926	29·856	45·9	41·1	W
2	30·155	30·090	29·971	29·944	48·0	39·8	W	2	29·769	29·685	29·721	29·757	43·7	35·5	W
3	29·824	29·679	29·707	29·814	42·4	37·1	NW	3	29·639	29·733	29·894	30·026	40·4	33·8	NW
4	29·902	29·977	30·020	30·116	39·7	34·6	N	4	30·070	30·186	30·240	30·274	37·4	30·9	N
5	30·166	30·228	30·222	30·264	40·6	33·0	N	5	30·263	30·231	30·171	30·134	37·4	26·5	NW
6	30·264	30·287	30·229	30·212	37·2	32·1	NE	6	30·046	30·013	30·066	30·153	45·4	35·5	W
7	30·218	30·318	30·313	30·315	44·1	33·2	NNE	7	30·151	30·186	30·116	29·905	44·8	36·4	W
8	30·156	29·913	29·668	29·686	45·5	32·1	SW	8	29·562	29·398	29·419	29·460	45·1	30·4	NW
9	29·664	29·775	29·840	29·838	37·3	31·8	NW	9	29·561	29·681	29·674	29·466	35·0	26·6	NW
10	29·557	29·211	28·916	29·858	48·7	32·3	SW	10	28·846	28·648	28·452	28·420	43·2	30·5	SW
11	28·856	28·917	29·097	29·281	43·3	34·6	W	11	28·606	28·920	29·085	29·190	37·9	33·6	WNW
12	29·384	29·478	29·524	29·565	40·9	30·6	W	12	29·262	29·346	29·386	29·343	41·1	33·2	W
13	29·518	29·468	29·434	29·465	39·9	27·9	S	13	29·266	29·226	29·196	29·236	36·9	29·7	SE
14	29·551	29·633	29·636	29·641	43·6	30·3	SW	14	29·315	29·382	29·410	29·418	38·1	33·4	S
15	29·563	29·604	29·693	29·696	43·4	35·6	W	15	29·387	29·416	29·375	29·138	41·2	33·5	SW
16	29·567	29·568	29·582	29·525	49·7	40·0	SW	16	29·048	29·231	29·275	29·365	42·5	34·6	W
17	29·502	29·603	29·672	29·784	48·2	39·9	NNE	17	29·444	29·568	29·673	29·792	44·2	31·8	W
18	29·832	29·869	29·799	29·741	44·1	39·5	NE	18	29·823	29·837	29·681	29·715	42·3	33·8	SE
19	29·751	29·734	29·652	29·762	46·0	38·8	S	19	29·627	29·610	29·608	29·738	39·3	33·9	E
20	29·899	30·041	30·084	30·175	45·4	34·7	WNW	20	29·842	29·936	30·018	30·098	43·2	32·6	WNW
21	30·183	30·222	30·177	30·189	44·3	29·4	NW	21	30·119	30·153	30·126	30·126	42·1	31·5	W
22	30·153	30·101	29·955	29·790	44·1	25·6	SSE	22	30·066	30·013	29·883	29·823	41·0	29·8	NE
23	29·607	29·555	29·567	29·656	38·7	31·4	ENE	23	29·751	29·739	29·668	29·610	39·2	30·9	ENE
24	29·692	29·728	29·728	29·710	41·5	29·9	W	24	29·555	29·529	29·445	29·274	37·1	27·0	NW
25	29·454	29·414	29·482	29·555	48·3	37·3	W	25	28·961	28·943	29·012	29·093	42·5	34·5	W
26	29·526	29·464	29·350	29·313	48·5	37·1	SW	26	29·108	29·121	29·107	29·118	41·1	33·8	SSW
27	29·227	29·196	29·251	29·405	45·7	36·0	W	27	29·107	29·231	29·419	29·631	39·5	33·7	N
28	29·627	29·847	29·824	29·742	45·0	34·2	NW	28	29·662	29·476	29·370	29·504	46·1	29·9	WSW

MARCH, 1906.

KEW.

Date.	Barometer. 4 A.M.	10 A.M.	4 P.M.	10 P.M.	Temperature. Max	Min.	Direction of wind at noon.
1	29·753	29·773	29·627	29·657	49·4	44·3	WSW
2	29·667	29·732	29·966	30·209	50·0	34·4	N
3	30·336	30·444	30·399	30·422	47·6	30·0	WSW
4	30·376	30·372	30·282	30·252	54·4	35·6	SW
5	30·124	30·107	30·105	30·188	51·5	33·9	SW
6	30·219	30·316	30·238	30·287	60·6	47·3	SSW
7	30·275	30·270	30·150	30·136	61·0	39·6	SSW
8	30·028	29·906	29·788	29·790	51·2	45·3	SW
9	29·794	29·854	29·860	29·955	48·4	40·0	WNW
10	30·000	30·029	29·921	29·758	48·3	36·4	SW
11	29·599	29·439	29·138	29·170	52·9	40·8	SW
12	29·248	29·375	29·702	29·920	40·7	32·1	NNW
13	29·858	29·885	29·866	29·824	39·1	29·6	WSW
14	29·757	29·915	30·064	30·075	43·8	33·0	NE
15	29·941	29·918	29·857	29·891	54·0	40·5	WSW
16	29·965	29·966	30·011	30·059	55·7	48·9	WSW
17	30·071	30·077	29·994	29·973	61·2	45·8	SW
18	29·928	29·917	29·875	29·893	49·4	38·2	W
19	29·858	30·074	30·161	30·265	43·8	37·1	N
20	30·265	30·228	30·086	30·026	44·9	36·3	NW
21	30·007	30·052	30·084	30·161	42·2	32·7	NE
22	30·168	30·176	30·096	30·032	40·3	30·7	NE
23	29·919	29·924	29·892	29·865	40·0	28·0	NE
24	29·787	29·718	29·637	29·640	40·7	32·0	NNE
25	29·588	29·617	29·595	29·674	41·1	31·6	N
26	29·693	29·744	29·757	29·834	41·5	30·4	NNE
27	29·859	29·936	29·917	30·018	43·5	33·9	NE
28	30·042	30·089	30·044	30·028	44·0	32·6	E
29	30·010	30·100	30·130	30·206	45·1	32·2	N
30	30·228	30·260	30·213	30·243	47·6	29·3	W
31	30·242	30·288	30·277	30·337	51·7	39·7	NW

GLASGOW.

Date.	Barometer. 4 A.M.	10 A.M.	4 P.M.	10 P.M.	Temperature. Max	Min.	Direction of wind at noon.
1	29·519	29·486	29·487	29·590	41·1	35·3	W
2	29·719	29·877	30·021	30·163	41·0	31·8	N
3	30·159	30·164	30·145	30·189	45·5	31·4	WNW
4	30·146	30·104	30·054	29·981	45·4	42·2	SW
5	29·858	29·791	29·718	29·804	47·4	41·3	SW
6	29·818	29·844	29·886	29·938	49·5	45·8	SW
7	29·914	29·844	29·659	29·672	48·8	44·0	SW
8	29·573	29·441	29·376	29·369	45·1	34·5	WSW
9	29·369	29·507	29·632	29·814	41·4	35·5	NW
10	29·863	29·846	29·724	29·632	43·0	31·4	S
11	29·348	28·981	28·862	28·988	39·5	32·9	NNE
12	29·178	29·523	29·684	29·756	35·1	27·1	NNW
13	29·742	29·752	29·747	29·767	33·0	23·9	NW
14	29·838	29·908	29·805	29·598	36·5	19·3	W
15	29·542	29·326	29·336	29·472	49·4	32·6	SW
16	29·552	29·550	29·452	29·529	50·3	37·3	SW
17	29·520	29·555	29·642	29·727	50·1	42·9	WSW
18	29·784	29·853	29·855	30·047	45·2	38·5	W
19	30·163	30·271	30·327	30·398	43·8	36·3	N
20	30·370	30·290	30·254	30·265	52·7	33·0	N
21	30·263	30·302	30·280	30·302	47·8	38·8	NNE
22	30·304	30·268	30·098	29·938	46·1	31·2	W
23	29·969	30·101	30·085	30·074	47·2	36·7	NNE
24	30·034	29·969	29·922	29·923	44·8	34·8	N
25	29·907	29·924	29·890	29·921	41·1	34·3	NNE
26	29·936	29·994	30·040	30·094	40·3	33·1	NE
27	30·100	30·132	30·142	30·184	43·6	33·1	NNE
28	30·172	30·134	30·059	30·066	50·5	29·1	W
29	30·094	30·149	30·137	30·166	48·4	35·1	N
30	30·151	30·163	30·140	30·181	50·1	38·8	WNW
31	30·203	30·254	30·275	30·325	49·3	38·2	NW

APRIL, 1906.

1	30·369	30·429	30·427	30·479	50·2	40·0	NNE
2	30·488	30·519	30·451	30·447	45·6	35·3	NE
3	30·396	30·400	30·324	30·316	59·6	36·6	ESE
4	30·255	30·190	30·026	29·963	55·5	36·3	SE
5	29·876	29·832	29·828	29·948	61·3	38·9	SE
6	30·091	30·276	30·334	30·462	58·3	38·3	NE
7	30·445	30·451	30·368	30·411	60·1	32·0	E
8	30·397	30·478	30·483	30·573	58·3	40·4	N
9	30·577	30·573	30·470	30·493	58·1	40·0	NE
10	30·427	30·392	30·273	30·271	62·2	36·2	NE
11	30·231	30·233	30·139	30·158	66·3	40·1	NE
12	30·126	30·104	30·031	30·053	71·1	40·3	S
13	30·015	30·048	30·027	30·139	67·9	49·1	SW
14	30·296	30·434	30·472	30·558	52·4	38·9	NNE
15	30·558	30·572	30·478	30·469	57·2	32·0	NE
16	30·394	30·318	30·148	30·068	63·4	32·4	W
17	29·964	29·874	29·769	29·784	59·3	38·0	NW
18	29·727	29·701	29·656	29·687	46·2	39·6	NNE
19	29·640	29·688	29·745	29·876	49·0	34·7	NNE
20	29·920	29·969	29·969	30·021	54·9	30·6	SW
21	30·023	30·015	29·915	29·866	58·6	42·0	W
22	29·839	29·990	29·872	29·967	55·0	40·7	W
23	30·015	30·093	30·067	30·089	49·5	35·5	NNW
24	30·035	29·972	29·898	29·813	48·0	32·4	NW
25	29·783	29·850	29·858	29·869	47·3	35·4	E
26	29·723	29·618	29·587	29·729	51·0	31·5	S
27	29·803	29·811	29·700	29·590	54·9	32·4	NW
28	29·362	29·366	29·342	29·348	50·1	35·4	WNW
29	29·331	29·343	29·327	29·356	49·7	32·3	SSW
30	29·366	29·446	29·465	29·543	49·0	35·4	NNE

1	30·346	30·394	30·406	30·444	49·4	40·9	W
2	30·469	30·474	30·439	30·437	52·2	40·1	S
3	30·427	30·397	30·249	30·187	55·6	33·5	S
4	30·073	29·955	29·795	29·768	56·4	41·5	S
5	29·714	29·767	29·872	30·075	52·1	43·0	NE
6	30·235	30·364	30·353	30·384	54·4	35·6	S
7	30·341	30·314	30·285	30·350	55·9	35·2	SW
8	30·416	30·372	30·605	30·651	54·1	44·9	W
9	30·669	30·635	30·555	30·543	60·1	36·0	W
10	30·489	30·444	30·327	30·329	62·2	37·2	N
11	30·301	30·277	30·161	30·165	61·4	36·4	NE
12	30·091	30·043	29·932	29·924	59·6	38·1	NE
13	29·875	29·900	30·012	30·209	54·5	40·1	W
14	30·313	30·395	30·018	30·426	51·9	36·0	W
15	30·364	30·345	30·278	30·236	52·5	42·1	SW
16	30·157	30·057	29·903	29·935	49·5	39·4	SSW
17	29·938	29·900	29·840	29·874	44·5	35·6	ESE
18	29·911	29·948	29·915	29·945	47·2	35·4	NNE
19	29·915	29·893	29·799	29·745	45·9	29·9	NNE
20	29·623	29·645	29·628	29·602	53·4	38·1	NW
21	29·546	29·488	29·506	29·524	49·5	38·9	WSW
22	29·492	29·682	29·822	29·994	50·6	38·6	W
23	30·049	30·065	30·022	29·974	45·9	36·0	NW
24	29·969	29·951	29·811	29·830	45·0	34·0	NNW
25	29·960	30·008	29·893	29·676	45·2	33·1	ESE
26	29·501	29·560	29·663	29·751	50·1	36·1	NE
27	29·718	29·602	29·351	29·287	47·2	36·0	SW
28	29·213	29·179	29·156	29·138	44·4	35·0	WNW
29	29·054	29·112	29·238	29·396	47·5	34·3	ENE
30	29·449	29·523	29·547	29·610	49·5	33·0	ENE

MAY, 1906.

KEW.								GLASGOW.							
	BAROMETER.				TEMPERATURE.				BAROMETER.				TEMPERATURE.		
Date.	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Max	Min.	Direction of wind at noon.	Date.	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Max	Min.	Direction of wind at noon.
1	29·569	29·636	29·646	29·703	54·4	34·1	NW	1	29·592	29·579	29·549	29·554	49·0	33·3	NW
2	29·714	29·746	29·707	29·685	50·6	36·9	S	2	29·544	29·509	29·404	29·332	46·4	33·5	S
3	29·707	29·765	29·746	29·773	59·3	47·5	SSW	3	29·394	29·446	29·447	29·490	52·5	43·2	S
4	29·798	29·895	29·978	30·107	60·0	48·6	SW	4	29·516	29·611	29·789	29·933	51·1	42·5	W
5	30·171	30·196	30·169	30·146	58·7	41·1	SW	5	29·962	29·912	29·794	29·727	49·4	36·5	SSE
6	30·083	30·104	30·102	30·131	56·0	50·0	SW	6	29·656	29·708	29·737	29·793	57·5	48·9	SSW
7	30·123	30·158	30·102	30·094	64·7	50·7	SSW	7	29·854	29·921	29·947	30·021	62·8	48·9	SSW
8	30·043	29·979	29·851	29·854	73·3	43·9	NNE	8	30·026	30·018	29·934	29·900	58·4	49·1	NW
9	29·783	29·779	29·742	29·777	59·8	48·4	NW	9	29·828	29·824	29·812	29·828	51·0	43·4	NE
10	29·741	29·761	29·724	29·737	49·6	45·0	NE	10	29·789	29·732	29·632	29·594	51·4	40·8	W
11	29·715	29·718	29·689	29·719	58·1	45·0	S	11	29·540	29·534	29·559	29·642	47·9	39·6	SE
12	29·730	29·804	29·841	29·938	70·0	49·4	SSE	12	29·707	29·807	29·903	30·001	58·4	45·2	N
13	29·958	29·996	29·931	29·971	71·3	50·8	NE	13	30·045	30·075	30·035	30·035	61·0	50·3	NE
14	29·906	29·887	29·865	29·896	63·2	47·0	NNE	14	30·050	30·085	30·028	30·017	56·3	46·2	NE
15	29·815	29·793	29·637	29·602	59·2	43·3	N	15	29·869	29·705	29·578	29·499	51·3	41·0	WNW
16	29·537	29·479	29·416	29·471	54·7	44·0	WNW	16	29·501	29·546	29·553	29·580	49·3	41·5	N
17	29·466	29·495	29·481	29·504	51·0	40·0	NNW	17	29·511	29·440	29·432	29·480	48·7	40·3	N
18	29·512	29·554	29·562	29·620	55·0	33·1	ENE	18	29·487	29·640	29·701	29·740	51·3	40·6	ENE
19	29·649	29·659	29·626	29·683	62·0	40·4	N	19	29·728	29·726	29·729	29·770	48·6	43·1	NE
20	29·695	29·716	29·735	29·778	49·8	41·9	NW	20	29·818	29·876	29·910	29·982	54·8	39·1	ENE
21	29·754	29·819	29·868	29·907	52·6	43·9	N	21	29·952	29·952	29·903	29·888	46·4	35·1	W
22	29·897	29·912	29·884	29·861	56·1	41·0	E	22	29·881	29·884	29·884	29·888	47·5	39·3	E
23	29·801	29·770	29·696	29·671	69·0	48·2	S	23	29·866	29·834	29·792	29·755	49·5	39·5	E
24	29·649	29·713	29·784	29·916	64·7	49·2	SW	24	29·704	29·710	29·668	29·652	48·5	44·0	ENE
25	29·980	30·026	30·030	30·077	62·5	45·7	SW	25	29·688	29·744	29·728	29·738	54·6	45·8	S
26	30·056	29·991	29·915	29·928	60·6	47·8	S	26	29·754	29·766	29·752	29·741	58·1	42·8	WSW
27	29·894	29·904	29·930	29·999	65·1	53·6	SW	27	29·710	29·708	29·708	29·708	64·7	48·1	SSW
28	29·954	30·036	30·047	30·061	71·8	56·3	SW	28	29·694	29·796	29·824	29·806	60·4	47·2	NE
29	30·058	30·057	30·041	30·074	69·5	53·8	W	29	29·769	29·810	29·798	29·776	55·7	51·0	SW
30	30·050	30·028	29·927	29·887	67·3	50·0	W	30	29·751	29·798	29·752	29·647	57·3	48·9	W
31	29·753	29·677	29·645	29·679	62·6	48·7	W	31	29·551	29·515	29·480	29·411	54·2	47·2	W

JUNE, 1906.

1	29·605	29·525	29·515	29·665	58·9	46·7	WSW	1	29·325	29·415	29·563	29·714	57·1	44·3	E
2	29·797	29·910	29·950	30·033	62·3	45·3	NW	2	29·817	29·895	29·949	30·031	68·1	48·4	W
3	30·088	30·157	30·181	30·216	68·3	48·3	NNW	3	30·082	30·131	30·181	30·216	63·1	46·9	W
4	30·251	30·321	30·338	30·378	60·6	46·9	NE	4	30·262	30·309	30·291	30·328	61·5	43·8	NE
5	30·372	30·377	30·311	30·351	64·3	41·2	NE	5	30·327	30·314	30·252	30·252	63·6	45·1	ENE
6	30·330	30·330	30·267	30·273	68·0	44·5	E	6	30·233	30·231	30·199	30·191	66·6	47·3	SW
7	30·257	30·230	30·182	30·193	71·2	42·5	NE	7	30·176	30·196	30·174	30·189	66·8	52·6	W
8	30·188	30·177	30·135	30·182	72·7	47·0	NE	8	30·193	30·219	30·186	30·182	69·4	50·6	NE
9	30·187	30·211	30·184	30·239	69·9	50·4	NE	9	30·194	30·215	30·199	30·217	69·5	49·4	W
10	30·249	30·252	30·196	30·236	68·6	47·3	NE	10	30·230	30·251	30·227	30·255	76·6	51·3	E
11	30·225	30·258	30·183	30·195	69·0	47·8	NE	11	30·261	30·253	30·182	30·183	78·0	54·3	NE
12	30·179	30·158	30·074	30·048	72·0	47·1	NE	12	30·164	30·138	30·101	30·146	73·2	52·2	W
13	30·047	30·092	30·084	30·121	61·5	48·6	NNE	13	30·136	30·159	30·139	30·144	67·0	51·8	E
14	30·107	30·113	30·079	30·082	56·0	48·5	N	14	30·124	30·121	30·050	30·082	66·1	50·6	WSW
15	30·023	29·974	29·916	29·930	57·8	47·5	N	15	30·061	30·072	30·094	30·154	59·2	50·1	E
16	29·935	29·950	29·917	29·970	63·1	47·1	NE	16	30·176	30·136	30·080	30·084	65·3	47·4	NE
17	29·953	29·984	29·989	30·060	68·4	49·2	S	17	30·081	30·071	30·041	30·043	58·9	51·6	E
18	30·095	30·129	30·110	30·176	72·1	45·2	S	18	30·084	30·079	30·059	30·125	66·0	51·2	ENE
19	30·213	30·248	30·231	30·300	75·8	51·0	W	19	30·145	30·164	30·162	30·189	68·6	48·5	SW
20	30·329	30·352	30·317	30·329	77·5	53·0	SSW	20	30·180	30·170	30·120	30·134	65·6	54·6	SW
21	30·320	30·315	30·255	30·229	76·5	58·6	W	21	30·150	30·180	30·134	30·094	65·5	57·3	W
22	30·177	30·150	30·092	30·093	75·7	61·1	NW	22	30·051	30·059	30·040	30·044	67·2	57·1	WSW
23	30·046	29·980	29·879	29·839	81·6	57·4	S	23	29·999	29·935	29·844	29·764	66·3	54·7	NNW
24	29·762	29·846	29·921	30·031	71·1	58·7	WNW	24	29·711	29·730	29·734	29·813	66·8	52·7	SW
25	30·086	30·110	30·064	30·076	70·1	55·6	SW	25	29·823	29·782	29·679	29·712	59·0	48·3	S
26	30·067	30·043	29·989	29·971	72·0	57·4	SW	26	29·724	29·698	29·643	29·629	62·4	51·9	SW
27	29·924	29·907	29·893	29·904	74·0	54·0	SW	27	29·609	29·647	29·700	29·744	59·9	51·0	WSW
28	29·873	29·839	29·775	29·720	74·3	56·9	SW	28	29·759	29·787	29·802	29·915	61·5	50·2	W
29	29·672	29·876	30·074	30·181	59·2	47·0	N	29	29·995	30·051	30·049	30·087	57·8	44·7	W
30	30·197	30·176	30·105	30·081	65·0	44·3	W	30	30·047	30·034	29·978	29·970	57·1	46·2	W

JULY, 1906.

KEW.								GLASGOW.							
	Barometer.				Temperature.				Barometer.				Temperature.		
Date.	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Max	Min.	Direction of wind at noon.	Date.	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Max	Min	Direction of wind at noon.
1	30·062	30·068	30·043	30·062	67·2	47·0	NNW	1	29·970	29·996	29·992	30·019	59·5	44·1	SE
2	30·062	30·081	30·047	30·089	70·3	49·7	E	2	30·014	30·022	29·999	30·031	62·9	48·8	SW
3	30·088	30·090	30·070	30·127	69·8	51·2	ENE	3	30·052	30·074	30·074	30·123	66·4	50·1	WNW
4	30·116	30·092	30·017	30·029	74·0	51·0	N	4	30·112	30·092	30·030	30·022	65·9	47·2	ENE
5	29·993	29·966	29·914	29·932	76·5	52·0	NE	5	29·978	29·938	29·843	29·843	72·7	50·3	NE
6	29·912	29·914	29·897	29·932	72·4	54·6	WSW	6	29·828	29·817	29·839	29·870	61·3	54·1	W
7	29·959	30·020	30·021	30·092	75·0	55·8	W	7	29·874	29·862	29·865	29·892	64·8	48·1	SW
8	30·105	30·142	30·154	30·188	76·0	56·7	WSW	8	29·925	30·034	30·100	30·160	63·7	52·5	W
9	30·216	30·240	30·212	30·204	72·1	55·2	N	9	30·165	30·177	30·173	30·136	62·9	49·7	W.W
10	—	30·150	30·116	30·164	69·6	53·0	E	10	30·116	30·121	30·112	30·160	61·9	51·5	W
11	30·153	30·160	30·135	30·173	65·9	51·6	N	11	30·163	30·176	30·156	30·178	61·8	45·1	WNW
12	30·172	30·180	30·139	30·154	65·0	51·7	N	12	30·182	30·166	30·093	30·032	65·9	45·1	W
13	30·105	30·078	30·040	30·017	66·5	47·0	W	13	29·956	29·896	29·858	29·882	62·4	52·8	SW
14	29·970	30·015	30·009	30·044	74·9	57·7	W	14	29·875	29·851	29·833	29·716	57·2	48·8	SW
15	29·987	29·950	29·910	30·017	70·7	55·8	WSW	15	29·564	29·712	29·750	29·812	59·1	51·6	W
16	30·033	30·008	29·970	30·005	73·1	51·3	W	16	29·750	29·624	29·620	29·710	59·5	49·2	W
17	30·029	30·068	30·019	30·011	78·4	59·7	W	17	29·790	29·774	29·749	29·700	61·6	51·0	SW
18	29·988	29·946	29·825	29·798	80·8	58·3	SW	18	29·659	29·601	29·489	29·399	65·1	54·3	SW
19	29·776	29·835	29·877	29·927	66·1	54·4	W	19	29·434	29·516	29·624	29·658	56·2	47·5	W
20	29·887	29·885	29·843	29·924	68·6	52·4	W	20	29·610	29·628	29·688	29·748	57·7	45·1	W
21	29·975	29·977	29·951	29·957	68·1	48·9	SW	21	29·768	29·823	29·708	29·798	67·0	46·2	W.W
22	29·951	29·971	29·954	30·008	78·0	63·8	WNW	22	29·757	29·763	29·708	29·873	67·5	57·0	SW
23	29·994	29·975	29·903	29·900	80·2	61·6	S	23	29·849	29·791	29·755	29·801	60·0	50·4	N
24	29·916	29·979	29·997	30·057	70·9	57·2	NW	24	29·827	29·867	29·887	29·949	59·2	49·8	SW
25	30·113	30·144	30·097	30·085	75·7	49·9	E	25	29·892	30·039	30·020	29·995	66·1	50·2	SW
26	30·014	29·939	29·840	29·830	75·1	55·8	E	26	29·932	29·884	29·793	29·766	73·0	54·8	ESE
27	29·802	29·817	29·840	29·917	76·1	59·1	NE	27	29·786	29·815	29·843	29·837	62·2	53·5	NE
28	29·913	29·925	29·895	29·913	74·5	56·1	SW	28	29·785	29·728	29·696	29·759	65·8	51·9	SE
29	29·910	29·928	29·932	29·947	73·0	59·2	NNW	29	29·793	29·851	29·861	29·903	70·1	53·4	WsW
30	29·922	29·907	29·861	29·862	80·1	59·2	E	30	29·902	29·862	29·832	29·812	63·4	51·9	ENE
31	29·811	29·880	29·900	30·007	77·7	59·9	W	31	29·783	29·766	29·754	29·827	64·0	56·7	E

AUGUST, 1906.

1	30·032	30·078	30·036	30·037	76·6	54·1	SW	1	29·871	29·895	29·855	29·820	65·1	52·8	SE
2	29·977	29·912	29·761	29·636	83·1	58·4	S	2	29·725	29·669	29·572	29·473	66·1	60·5	SSE
3	29·699	29·760	29·787	29·851	73·1	59·0	SW	3	29·425	29·460	29·460	29·510	63·0	56·4	SW
4	29·911	29·995	30·044	30·164	72·5	57·3	WSW	4	29·592	29·509	29·818	29·914	61·5	54·4	SW
5	30·188	30·231	30·196	30·206	75·0	54·9	SW	5	29·954	30·028	30·088	30·114	60·9	53·1	WSW
6	30·197	30·200	30·143	30·129	77·7	58·0	WSW	6	30·128	30·144	30·115	30·098	71·3	47·7	SW
7	30·101	30·079	30·021	30·034	80·8	57·7	SW	7	30·060	30·018	29·964	29·977	65·0	54·5	NE
8	30·006	29·963	29·845	29·816	82·0	58·8	S	8	29·955	29·927	29·836	29·824	69·4	56·4	SW
9	29·827	29·859	29·840	29·813	74·3	57·2	W	9	29·777	29·777	29·751	29·751	63·9	54·5	W
10	29·808	29·790	29·714	29·719	70·9	58·9	SW	10	29·692	29·644	29·583	29·606	58·6	52·1	SE
11	29·707	29·754	29·795	29·829	68·3	55·3	NW	11	29·655	29·713	29·707	29·711	60·8	51·7	ENE
12	29·817	29·832	29·816	29·799	69·9	56·0	SSW	12	29·658	29·607	29·566	29·538	60·1	53·2	E
13	29·705	29·626	29·581	29·626	77·9	60·8	S	13	29·415	29·402	29·353	29·404	63·4	57·4	SE
14	29·651	29·657	29·619	29·676	71·7	57·6	S	14	29·435	29·430	29·383	29·414	66·2	53·2	SSE
15	29·714	29·750	29·730	29·790	69·7	55·9	SW	15	29·413	29·452	29·466	29·488	63·4	54·2	SW
16	29·810	29·837	29·817	29·844	67·6	52·9	WSW	16	29·499	29·537	29·574	29·625	59·8	52·1	W
17	29·804	29·812	29·804	29·851	65·0	53·3	W	17	29·624	29·638	29·687	29·797	58·0	51·5	WNW
18	29·847	29·946	30·001	30·091	64·6	50·9	NNW	18	29·851	29·932	29·977	30·040	63·8	49·3	WNW
19	30·110	30·174	30·153	30·178	66·7	52·0	NW	19	30·037	30·051	30·015	29·953	60·1	46·2	W
20	30·142	30·118	30·072	30·090	71·6	50·6	SW	20	30·082	29·704	29·744	29·873	64·1	54·4	WSW
21	30·092	30·111	30·106	30·094	76·6	61·6	W	21	29·902	29·953	29·951	29·904	62·4	53·1	SW
22	30·044	29·995	29·896	29·897	86·0	56·4	S	22	29·788	29·804	29·827	29·862	62·2	53·1	SW
23	29·855	29·916	29·928	29·988	81·1	56·9	SW	23	29·908	29·975	29·946	29·908	59·7	50·2	ENE
24	29·955	29·940	29·913	29·913	75·1	62·4	SW	24	29·840	29·826	29·753	29·663	65·3	50·5	N
25	29·723	29·705	29·888	30·043	68·7	56·3	W	25	29·465	29·557	29·735	29·875	60·8	52·8	W
26	30·096	30·130	30·100	30·128	72·4	54·7	SW	26	29·908	29·896	29·904	29·997	62·5	50·1	SE
27	30·140	30·188	30·220	30·345	75·5	59·0	N	27	30·079	30·195	30·241	30·296	61·2	52·1	SE
28	30·382	30·411	30·334	30·345	70·3	52·3	E	28	30·296	30·309	30·250	30·220	69·7	55·7	WSW
29	30·302	30·280	30·178	30·172	74·6	46·0	ESE	29	30·157	30·140	30·099	30·065	70·0	57·9	SW
30	30·124	30·122	30·047	30·065	83·4	48·6	E	30	30·025	30·036	29·974	29·979	70·7	51·3	SW
31	30·059	30·069	30·041	30·079	90·9	55·9	S	31	29·969	29·981	29·945	29·965	76·2	49·2	SW

SEPTEMBER, 1906.

KEW.

Date.	Barometer. 4 A.M.	10 A.M.	4 P.M.	10 P.M.	Temperature. Max	Min.	Direction of wind at noon.
1	30·041	30·043	29·972	29·987	91·7	60·4	SE
2	29·960	29·958	29·904	29·940	91·7	59·6	SSE
3	29·928	29·932	29·937	30·041	84·9	57·0	SW
4	30·076	30·101	30·080	30·092	75·3	59·7	N
5	30·078	30·117	30·024	30·013	70·9	53·8	N
6	29·914	29·938	29·952	30·032	72·9	59·5	W
7	30·056	30·118	30·068	30·071	73·5	59·7	SW
8	30·054	30·085	30·058	30·116	77·1	55·4	W
9	30·156	30·219	30·199	30·255	67·5	53·3	N
10	30·258	30·279	30·250	30·321	64·0	47·8	N
11	30·318	30·342	30·262	30·267	68·6	42·3	SW
12	30·224	30·206	30·157	30·134	69·0	44·2	S
13	30·050	29·997	29·874	29·791	69·3	54·9	S
14	29·815	29·814	29·745	29·721	67·0	52·0	SW
15	29·538	29·597	29·571	29·610	63·0	50·0	W
16	29·702	29·826	29·908	30·000	58·2	48·6	NW
17	29·993	30·066	30·157	30·182	64·4	51·4	N
18	30·045	30·160	30·155	30·141	64·0	55·0	ENE
19	30·111	30·122	30·115	30·167	60·6	55·4	N
20	30·165	30·195	30·207	30·264	63·3	51·4	N
21	30·274	30·320	30·288	30·329	63·9	50·7	?
22	30·327	30·365	30·326	30·373	62·7	49·8	N
23	30·384	30·420	30·392	30·442	59·5	49·6	NNE
24	30·420	30·435	30·417	30·434	61·6	49·0	E
25	30·446	30·483	30·474	30·527	59·7	44·7	E
26	30·539	30·583	30·548	30·580	61·1	40·8	NE
27	30·588	30·601	30·542	30·564	64·6	38·9	E
28	30·522	30·527	30·406	30·383	60·0	38·6	SE
29	30·342	30·326	30·241	30·249	60·6	37·4	ENE
30	30·225	30·220	30·124	30·130	66·3	41·2	E

GLASGOW.

Date.	Barometer. 4 A.M.	10 A.M.	4 P.M.	10 P.M.	Temperature. Max	Min.	Direction of wind at noon.
1	29·959	29·959	29·900	29·869	83·5	54·6	NW
2	29·851	29·848	29·808	29·876	81·7	59·5	NE
3	29·899	29·946	30·010	30·064	65·9	53·7	W
4	30·090	30·109	30·081	30·051	62·1	47·2	WSW
5	29·968	29·881	29·669	29·581	58·9	53·5	SW
6	29·653	29·767	29·789	29·819	61·0	53·0	W
7	29·803	29·859	29·869	29·834	62·0	55·2	SW
8	29·847	29·909	29·964	30·035	61·1	52·4	W
9	30·071	30·133	30·173	30·221	58·9	49·4	W
10	30·244	30·279	30·250	30·262	59·2	44·6	SW
11	30·221	30·168	30·087	30·047	63·5	42·4	S
12	29·984	30·037	30·020	29·915	62·2	51·0	W
13	29·776	29·714	29·658	29·638	59·6	50·6	S
14	29·507	29·473	29·494	29·375	57·5	48·0	W
15	29·273	29·295	29·347	29·479	56·2	47·5	SW
16	29·624	29·804	29·934	30·062	59·9	47·6	NNW
17	30·128	30·223	30·275	30·345	61·8	39·9	W
18	30·389	30·394	30·345	30·337	59·8	46·5	E
19	30·290	30·288	30·265	30·287	57·7	53·0	NE
20	30·286	30·305	30·301	30·339	59·8	50·3	NE
21	30·343	30·388	30·379	30·387	60·4	52·1	E
22	30·374	30·389	30·380	30·439	62·7	45·5	N
23	30·464	30·510	30·484	30·518	57·5	47·4	E
24	30·515	30·498	30·441	30·443	56·1	40·2	E
25	30·427	30·443	30·444	30·473	58·5	48·2	SSW
26	30·488	30·512	30·497	30·502	58·3	48·4	WSW
27	30·498	30·509	30·471	30·489	59·8	47·9	S W
28	30·457	30·457	30·377	30·365	59·9	40·5	W
29	30·317	30·315	30·225	30·216	62·3	37·6	WSW
30	30·180	30·156	30·049	30·040	60·5	36·9	NW

OCTOBER, 1906.

1	30·079	30·060	29·973	29·898	68·4	47·3	S	1	29·964	29·917	29·746	29·643	60·0	47·6	SE
2	29·750	29·711	29·439	29·164	62·6	58·4	SSW	2	29·566	29·538	29·483	29·568	58·7	41·2	WSW
3	29·529	29·787	29·884	29·944	62·1	56·0	NNW	3	29·640	29·771	29·812	29·869	57·1	48·9	W
4	29·950	29·934	29·856	29·797	61·9	51·6	S	4	29·868	29·822	29·708	29·556	57·1	49·0	E
5	29·725	29·745	29·755	29·853	65·2	57·4	SSW	5	29·484	29·510	29·549	29·676	58·8	52·1	SW
6	29·933	30·006	30·012	30·015	63·5	51·0	SW	6	29·728	29·768	29·730	29·700	58·9	46·4	SSW
7	29·976	29·963	29·903	29·854	65·2	55·6	S	7	29·636	29·630	29·598	29·630	63·1	52·3	SSW
8	29·799	29·814	29·756	29·766	63·5	54·0	S	8	29·561	29·508	29·516	29·585	58·1	51·7	SE
9	29·776	29·823	29·824	29·819	60·2	51·4	SE	9	29·628	29·742	29·788	29·852	59·4	51·0	E
10	29·795	29·819	29·780	29·759	67·2	56·0	ENE	10	29·816	29·784	29·774	29·778	60·5	53·0	NE
11	29·703	29·743	29·714	29·733	69·3	53·2	SSE	11	29·750	29·740	29·647	29·572	58·9	53·4	E
12	29·749	29·762	29·718	29·702	62·9	52·7	SW	12	29·500	29·540	29·531	29·542	55·6	46·0	W
13	29·595	29·573	29·549	29·641	54·4	42·2	NW	13	29·539	29·580	29·671	29·829	46·6	37·3	N
14	29·740	29·885	29·926	29·960	51·6	37·9	N	14	29·854	29·820	29·687	29·599	52·5	32·6	SSW
15	29·873	29·816	29·726	29·715	59·6	37·6	SW	15	29·465	29·439	29·409	29·396	53·1	45·2	SW
16	29·676	29·704	29·687	29·757	59·5	50·2	S W	16	29·370	29·350	29·359	29·380	51·9	42·4	SW
17	29·743	29·805	29·826	29·880	59·2	50·3	W	17	29·382	29·454	29·526	29·684	49·5	40·0	SW
18	29·821	29·769	29·713	29·643	61·4	53·2	S	18	29·742	29·804	29·828	29·840	47·3	39·4	NE
19	29·608	29·740	29 773	29·824	57·8	44·1	SW	19	29·743	29·671	29·518	29·468	42·2	37·9	NW
20	29·847	29·899	29·842	29·813	57·9	37·9	WSW	20	29·523	29·657	29·702	29·726	51·7	39·4	W
21	29·856	29·923	29·913	29·932	66·5	53·6	S	21	29·702	29·769	29·751	29·744	57·4	42·6	NE
22	29·893	29·873	29·871	29·930	65·8	54·9	SW	22	29·659	29·615	29·504	29·612	59·7	53·5	SSE
23	29·929	30·022	30·031	30·087	62·3	52·0	SW	23	29·653	29·698	29·724	29·775	58·2	50·1	S
24	30·088	30·124	30·136	30·245	62·8	44·6	SW	24	29·860	29·944	30·025	30·118	52·1	44·0	SW
25	30·304	30·372	30·384	30·405	54·8	38·3	N	25	30·189	30·269	30·247	30·157	51·1	39·1	SSW
26	30·311	30·231	30·080	30·018	56·0	35·0	N	26	29·987	29·809	29·669	29·766	53·2	46·5	S
27	29·949	30·041	30·053	30·054	52·0	39·4	NW	27	29·833	29·881	29·737	29·578	50·7	40·5	S W
28	29·926	29·768	29·525	29·507	54·5	39·3	SSW	28	29·388	29·226	29·190	29·200	51·5	37·7	WSW
29	29·539	29·610	29·522	29·453	51·5	40·9	SW	29	29·186	29·176	29·136	29·162	41·8	35·3	SW
30	29·270	29·181	29·187	29·236	49·3	43·6	S	30	29·216	29·329	29·332	29·351	43·1	33·1	NE
31	29·337	29·476	29·498	29·471	49·9	41·5	N	31	29·321	29·534	29·595	29·640	53·9	42·1	E

NOVEMBER, 1906.

KEW.								GLASGOW.							
	Barometer.				Temperature.				Barometer.				Temperature.		
Date.	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Max	Min.	Direction of wind at noon.	Date.	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Max	Min.	Direction of wind at noon.
1	29·373	29·314	29·225	29·193	52·7	48·6	N	1	29·569	29·494	29·363	29·244	49·4	48·0	NE
2	29·180	29·178	29·186	29·256	51·3	41·9	W	2	29·160	29·137	29·007	28·946	50·2	47·9	NE
3	29·263	29·327	29·367	29·393	53·0	40·4	SSW	3	29·058	29·272	29·343	29·377	50·2	44·4	SE
4	29·362	29·279	29·089	28·939	48·4	41·0	ESE	4	29·355	29·489	29·457	29·393	50·2	41·2	NE
5	29·278	29·518	29·620	29·718	52·9	35·4	SW	5	29·388	29·445	29·485	29·546	49·1	41·1	N
6	29·719	29·681	29·504	29·316	51·3	33·2	NNE	6	29·587	29·663	29·682	29·732	44·4	36·8	NNW
7	29·318	29·383	29·416	29·419	53·5	47·3	SE	7	29·701	29·696	29·656	29·672	50·4	35·2	NNE
8	29·344	29·299	29·244	29·295	52·0	49·9	N	8	29·687	29·729	29·786	29·852	50·0	44·3	NNE
9	29·398	29·592	29·755	29·917	53·0	46·0	NNE	9	29·902	30·034	30·105	30·231	46·3	39·4	NNE
10	30·022	30·199	30·291	30·422	49·8	41·4	NE	10	30·300	30·380	30·414	30·430	42·6	35·0	N
11	30·448	30·504	30·472	30·488	47·7	31·6	NNE	11	30·420	30·417	30·410	30·400	45·6	37·4	WSW
12	30·482	30·486	30·440	30·453	45·4	29·4	NNE	12	30·379	30·397	30·376	30·378	46·2	43·1	SW
13	30·445	30·458	30·407	30·410	42·0	32·1	NNE	13	30·370	30·357	30·298	30·261	46·4	39·4	SW
14	30·369	30·353	30·261	30·203	47·0	39·3	E	14	30·173	30·073	29·908	29·836	48·3	42·2	S
15	30·077	30·006	29·657	29·709	50·7	40·0	SW	15	29·778	29·596	29·563	29·704	47·0	39·2	SSE
16	29·881	29·878	29·522	29·500	53·1	40·5	SW	16	29·678	29·559	29·310	29·248	42·6	38·5	SE
17	29·484	29·394	29·306	29·394	52·2	43·6	SW	17	29·098	28·939	28·869	28·946	46·2	38·1	SW
18	29·292	29·157	29·054	29·112	46·7	34·4	SSW	18	28·963	28·954	28·937	28·952	41·7	33·2	SW
19	29·125	29·175	29·225	29·330	42·7	29·7	SW	19	28·955	28·977	29·022	29·136	42·1	34·2	WNW
20	29·441	29·623	29·737	29·775	44·1	37·1	WNW	20	29·198	29·350	29·468	29·507	43·4	37·8	W
21	29·632	29·680	29·863	30·009	56·0	41·3	W	21	29·469	29·558	29·622	29·604	45·3	36·5	E
22	30·153	30·299	30·370	30·485	59·0	49·5	SW	22	29·676	29·822	29·915	30·045	57·3	44·8	SW
23	30·484	30·536	30·513	30·535	54·9	44·9	SW	23	30·087	30·129	30·142	30·205	56·7	54·1	SW
24	30·517	30·536	30·514	30·527	51·8	47·4	SSW	24	30·182	30·189	30·206	30·281	56·5	50·0	SSW
25	30·503	30·509	30·500	30·521	50·1	44·6	W	25	30·272	30·279	30·315	30·356	53·2	50·7	SW
26	30·501	30·463	30·367	30·265	50·4	40·9	SW	26	30·280	30·169	30·065	29·928	53·0	48·3	SW.
27	30·057	30·012	30·079	30·165	56·0	43·6	NW	27	29·813	29·878	29·949	29·989	50·0	45·9	W
28	30·199	30·189	30·149	30·157	52·3	39·5	SW	28	29·893	29·822	29·797	29·747	53·4	46·2	WSW
29	30·120	30·107	30·101	29·992	55·3	50·9	WSW	29	29·707	29·803	29·590	29·345	55·9	46·3	SW
30	29·873	29·822	29·811	29·848	55·4	40·0	NW	30	29·563	29·614	29·599	29·616	56·0	37·8	W

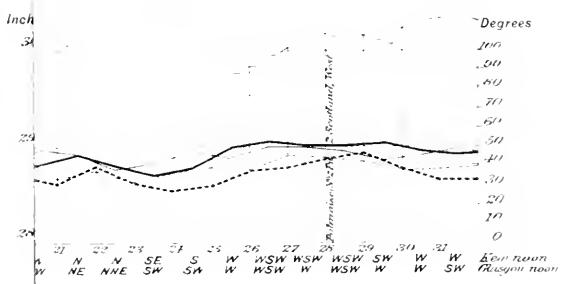
DECEMBER, 1906.

1	29·816	29·977	30·143	30·274	45·5	34·9	NW	1	29·823	30·036	30·113	30·050	42·1	37·2	W
2	30·294	30·172	30·098	30·110	52·0	34·3	SW	2	29·782	29·771	29·765	29·680	52·4	38·7	WSW
3	30·006	29·912	29·958	30·011	55·0	47·2	W	3	29·576	29·551	29·602	29·801	52·1	42·6	W
4	30·042	30·059	30·020	29·926	54·0	47·2	W	4	29·857	29·880	29·696	29·566	52·4	43·9	W
5	29·735	29·580	29·401	29·242	53·1	40·3	WNW	5	29·402	29·199	28·906	29·454	49·0	36·1	WSW
6	29·485	29·812	29·973	30·179	46·5	38·6	N	6	29·792	30·104	30·249	30·324	44·6	36·1	N
7	30·281	30·379	30·349	30·325	41·7	30·2	N	7	30·281	30·223	30·082	29·968	46·1	34·9	SW
8	30·228	30·094	29·883	29·749	44·5	30·0	SW	8	29·824	29·739	29·564	29·483	47·8	36·0	WSW
9	29·605	29·636	29·705	29·764	43·6	32·6	NNW	9	29·486	29·683	29·742	29·817	37·7	32·2	W
10	29·791	29·864	29·875	29·893	36·5	28·2	NW	10	29·854	29·890	29·839	29·786	35·3	30·5	W
11	29·849	29·843	29·774	29·680	45·1	27·4	WSW	11	29·674	29·616	29·573	29·486	39·1	33·4	WSW
12	29·602	29·445	29·481	29·623	45·1	37·0	WSW	12	29·250	29·145	29·214	29·364	41·4	33·6	N
13	29·677	29·548	29·451	29·462	39·3	33·3	S.W	13	29·360	29·263	29·284	29·287	38·0	31·9	W
14	29·432	29·572	29·714	29·849	40·4	33·4	WNW	14	29·298	29·476	29·666	29·795	37·4	31·7	W
15	29·949	30·038	30·068	30·111	38·0	32·6	SW	15	29·843	29·898	29·903	29·895	36·6	27·1	W
16	30·124	30·149	30·181	30·268	44·4	35·0	S	16	29·835	29·916	29·988	30·066	50·0	34·0	E
17	30·312	30·372	30·366	30·372	48·0	42·8	S	17	30·093	30·136	30·129	30·139	50·7	46·7	SW
18	30·343	30·366	30·366	30·420	49·1	43·5	SW	18	30·170	30·228	30·268	30·297	50·8	47·3	SW
19	30·454	30·523	30·517	30·557	45·1	38·4	ESE	19	30·290	30·316	30·318	30·369	48·4	46·0	SW
20	30·595	30·611	30·585	30·573	40·3	35·0	E	20	30·407	30·438	30·450	30·498	48·2	43·4	SW
21	30·555	30·566	30·549	30·514	40·1	31·9	ENE	21	30·508	30·554	30·542	30·528	45·6	43·3	SW
22	30·467	30·437	30·331	30·343	37·8	29·3	NE	22	30·508	30·499	30·390	30·316	44·0	36·0	SW
23	30·329	30·341	30·317	30·358	30·8	27·4	NW	23	30·218	30·202	30·115	30·098	41·7	36·3	SW
24	30·305	30·251	30·054	29·838	42·7	25·7	W	24	30·049	29·927	29·652	29·828	44·2	33·9	SW
25	29·857	29·910	29·843	29·688	42·4	30·8	NW	25	29·860	29·878	29·716	29·487	35·0	26·2	NW
26	29·069	28·957	29·122	29·168	35·2	23·3	N	26	29·304	29·280	29·022	29·175	34·3	21·8	W
27	29·127	29·279	29·351	29·368	35·0	24·5	NW	27	29·263	29·283	29·319	29·451	34·5	28·6	W
28	29·359	29·422	29·411	29·493	35·7	27·9	W	28	29·492	29·623	29·724	29·846	34·7	30·3	N
29	29·621	29·757	29·812	29·841	36·0	28·0	N	29	29·853	29·823	29·751	29·711	33·4	23·9	NW
30	29·784	29·781	29·684	29·582	35·3	26·4	S	30	29·636	29·565	29·437	29·452	30·6	23·4	NE
31	29·531	29·567	29·495	29·510	41·3	34·5	SW	31	29·437	29·368	29·158	29·193	37·4	28·5	ENE

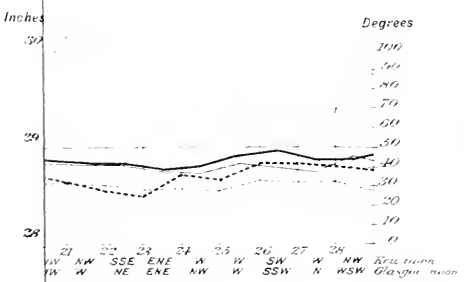
INIMA TEMPERATURES, AND THE DIRECTION
TOGETHER WITH THE EXPLOSIONS
TLAND.

1906.

JANUARY.



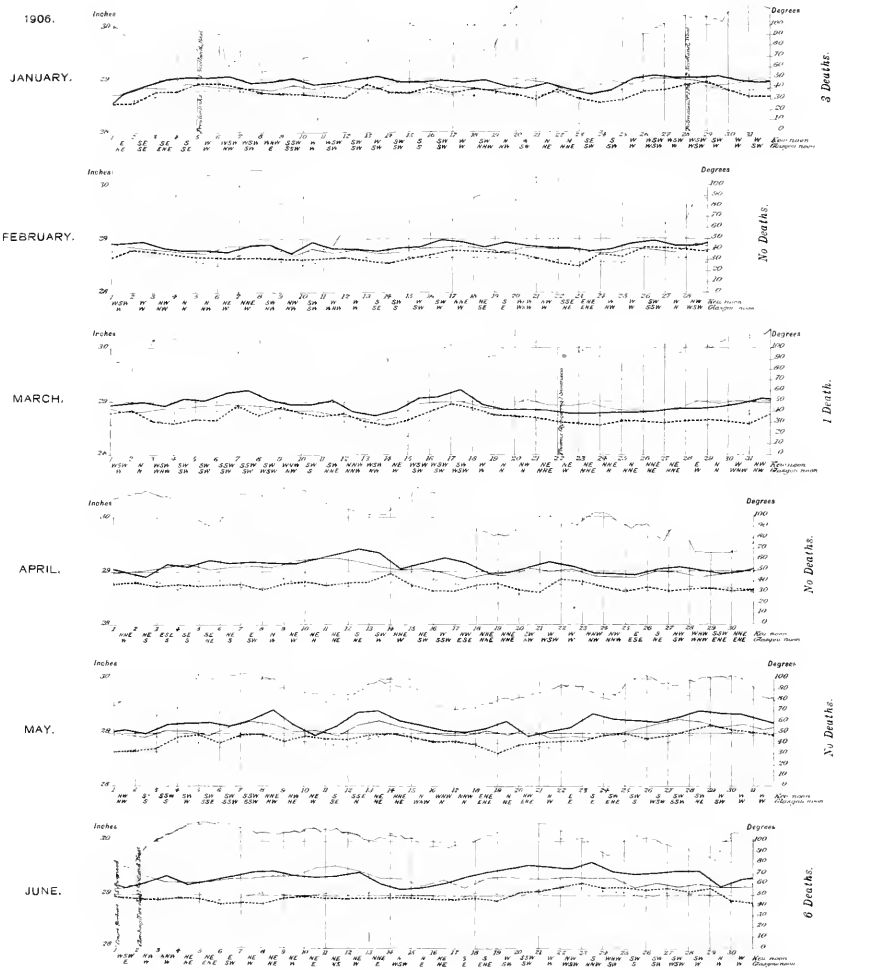
FEBRUARY.



MARCH.

DIAGRAM SHEWING THE HEIGHT OF THE BAROMETER, THE MAXIMA AND MINIMA TEMPERATURES, AND THE DIRECTION OF THE WIND AT THE OBSERVATORIES OF KEW AND GLASGOW, TOGETHER WITH THE EXPLOSIONS OF FIRE-DAMP IN ENGLAND AND SCOTLAND.

1906.

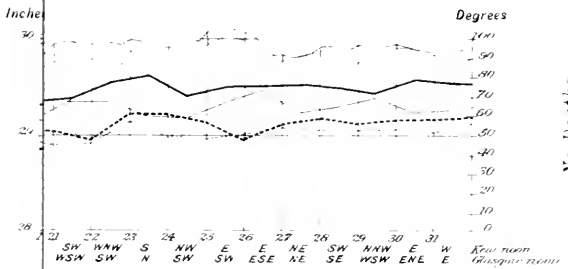


The firm top line is the Barometer reading at Kew, taken at 4 a.m., 10 a.m., 4 p.m., and 10 p.m.
The dotted top line is the Barometer reading at Glasgow, taken at 4 a.m., 10 a.m., 4 p.m., and 10 p.m.
The lower lines are the Maxima and Minima Temperatures at Kew and Glasgow, observed respectively at midnight and 9 p.m.
Kew lines are thick and Glasgow lines are thin.
The figures attached to the districts shew the Number of Deaths caused by the Explosions.

NIMA TEMPERATURES, AND THE DIRECTION
OGETHER WITH THE EXPLOSIONS
LAND.

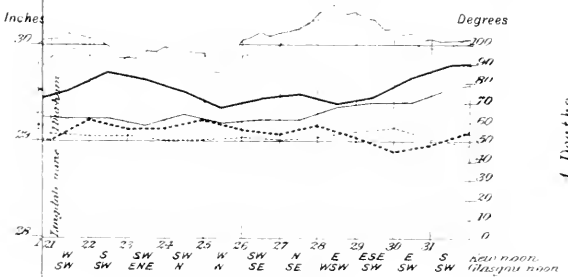
1906.

JULY.



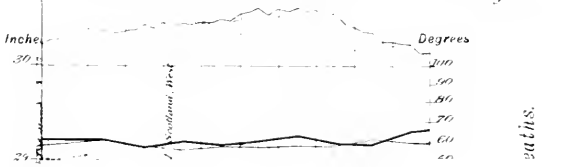
No Deaths.

AUGUST.



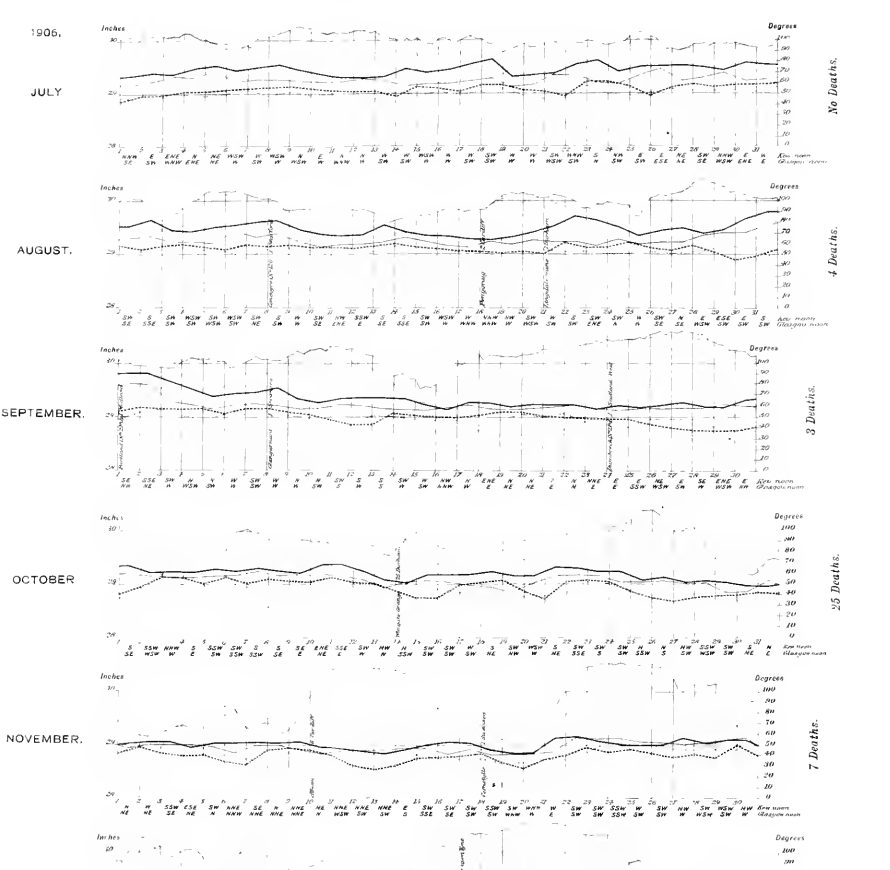
4 Deaths.

SEPTEMBER.



paths.

DIAGRAM SHEWING THE HEIGHT OF THE BAROMETER, THE MAXIMA AND MINIMA TEMPERATURES, AND THE DIRECTION OF THE WIND AT THE OBSERVATORIES OF KEW AND GLASGOW TOGETHER WITH THE EXPLOSIONS OF FIRE-DAMP IN ENGLAND AND SCOTLAND.



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THE NORTH OF ENGLAND INSTITUTE

OF

Mining and Mechanical Engineers.

ANNUAL REPORT OF THE COUNCIL

AND

ACCOUNTS FOR THE YEAR 1906-1907;

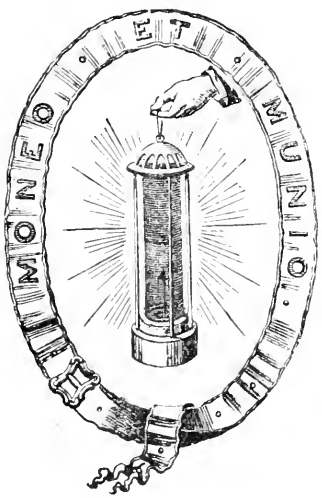
LIST OF

COUNCIL, OFFICERS AND MEMBERS

FOR THE YEAR 1907-1908:

THE CHARTER AND BYE-LAWS; Etc.

1906-1907.



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1907.

CONTENTS.

	PAGE.
Annual Report of the Council, 1906-1907	iii
Annual Report of the Finance Committee	viii
General Statement, June 30th, 1907	ix
The Treasurer in Account with The North of England Institute of Mining and Mechanical Engineers for the Year ending June 30th, 1907	x
The Treasurer of The North of England Institute of Mining and Mechanical Engineers in Account with Subscriptions, 1906 1907	xii
List of Committees appointed by the Council, 1907 1908	xiv
Officers, 1907-1908	xv
Patrons	xvi
Honorary Members	xvi
Members	xvii
Associate Members	xliii
Associates	xlvii
Students	liii
Subscribers	liv
Brief Syllabus of the Three Years' Course of Lectures for Colliery Engineers, Enginewrights, Apprentice Mechanics and Others	lvi
List of Transactions and Journals of Societies, etc., in the Library	lix
Charter of The North of England Institute of Mining and Mechanical Engineers	lxx
Bye-laws	lxxiii
Appendix to the Bye-laws	lxxix
Miners' Eight-hours Day Committee: Evidence by Mr. J. H. Merivale on behalf of The North of England Institute of Mining and Mechanical Engineers	lxxxv
Plate I.	*To face* lxxxviii
Memoir of the late Mr. George Henry Evans	lxxxix

THE NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

ANNUAL REPORT OF THE COUNCIL, 1906-1907.

The Institute has sustained great losses through the death of Mr. John Daglish, a past-president of the Institute, and one of its original members; and through the death of Mr. William Fairbairn Hall, a member since 1858, and a vice-president, 1892-1896.

The following table shows the variation of the membership during recent years:—

Year ending August 1st.	1901.	1904.	1907.
Honorary members	28	26	21
Members	880	955	903
Associate members	122	115	108
Associates	116	163	194
Students	57	66	47
Subscribers	23	25	34
Totals	1,226	1,350	1,307

The decrease of 42 names in the membership during the past year is due to an exceptional decrease in the number of members elected.

The deaths (19) include the following:—Honorary members: Prof. Alexander Stewart Herschel and Sir Charles Mark Palmer, Bart. Members: Charles William Anderson, James Barnet Bawden, William Charlton, Thomas Croudace, John Daglish, Patrick Doyle, George Henry Evans, Alfred Fellows, Cornelius Ferguson, David Henry Haggie, Peter Sinclair Haggie, William Fairbairn Hall, James Hilton, Richard Forster Matthews, John Stanton, Hugh Waddle and Collingwood Lindsay Wood.

The resignations (53) include the following:—Honorary members: Prof. George Stewardson Brady,* Sir Archibald Geikie* and Joseph Thomas Robson.* Members: Daniel Henry Bayldon, Charles Bertram, John Charles Binks, William Stevenson Blackburn, Jethro Longridge Brown, Henry Hunter Campbell, William Clark, Francis Coulthard, Charles Herbert Crone, John Henry Darby, Kenneth Davis, Konrad Ernst Richard Engel, Gathorne John Fisher, George Ernest Gregson, Richard Hartley, William Johnson, William James Larke, Albert Littlejohn, James Malcolm Maclaren, James Jones Meldrum, Arthur Herbert Meysey-Thompson, George Appleby Bartram Miller, Charles John Potter, William Reginald Potter, John Alsop Ramsay, Thomas Arthur Rickard, Gilbert Pitcairn Simpson, James Stewart, Philip Ibotson Unwin, John Vaughan and Edmund Bessell Whalley. Associate members: Thomas John Armstrong,

* Expiration of term of office.

Arthur Herbert Gray, Arthur O'Connor, K.C., Charles Henry de Rusett, Samuel Stewart, Henry Gilbert Stokes, Oswald Thompson and Andrew Selby Wood. Associates: William P. Armstrong, John Chipchase, Silas Scrafton Cowley, George Daykin, William James Knight, Charles Anthony Nelson, William Robson, jun., Joseph Cresswell Roscamp and John William Wilkinson. Student: Francis George Maynard. Subscribers: Messrs. A. Goerz & Company, Limited.

The following gentlemen (32) have ceased to be members during the past year:—Members: Ernest Akerman, Thomas Johnson Britten, Theodore B. Comstock, Arthur Edwin Dixon, John Buckman Esuman-Gwira, John James Constant Fernau, Harold Fletcher, Edgar Tom Gardiner, George Douglas Gibson, Martin Stanger Higgs, Frederick John Holman, Émile de Hulster, George Anderson Richard, John Robinson, Joseph Thompson, John Tizzard, T. Trevaillé-Williams and John James Whitehead. Associate members: Philippe Davidson Ahier, Leonard J. Bates, Charles J. Collopy, Horace William Jarvis, Ishmael Minnow and Samuel Thompson. Associates: Hugh M. Eddowes, John Fewster, Charles C. Greene, Bernard Jaeger, William Oliver and Sydney Richardson. Students: Alfred Potts and William Wilson.

The Library has been maintained in an efficient condition during the year; the additions, by donation, exchange and purchase, include 394 bound volumes and 26 pamphlets, reports, etc.; and the Library now contains about 11,300 volumes and 363 unbound pamphlets. A card-catalogue of the books, etc., contained in the Library renders them readily available for reference.

Members would render useful service to the profession by presentations of books, reports, plans, etc., to the Institute, to be preserved in the Library, and thereby become available for reference.

The following portraits of past-presidents of the Institute, for insertion in the panels in the Lecture Theatre, have been presented during the year:—The late Lord Armstrong, by Lord Armstrong; the late Sir Lothian Bell, Bart., by Sir Hugh Bell, Bart.; the late Sir George Elliot, Bart., by Sir Charles Elliot, Bart.; Sir Lindsay Wood, Bart.; Mr. William Armstrong; the late Mr. William Cochrane, by Mr. Cecil A. Cochrane; Mr. Thomas Douglas; Mr. Addison Langhorne Steavenson; and Mr. William Outterson Wood.

The following presentations have been received:—Vale of Derwent Field Club, *Transactions*; and Mr. R. W. Moore, on behalf of Miss Wilson, of Whitehaven, copies of reports made by Mr. J. B. Longmire, in 1817, on coal-fields near Moscow, Russia.

The courses of lectures for colliery engineers, enginewrights, and apprentice mechanics have been continued at Armstrong College, Newcastle-upon-Tyne. The lectures are delivered on Saturday afternoons, and the three years' course embraces the following subjects:—

1907-1908. Michaelmas Term, (1) The Steam-engine, and (2) Theoretical Electricity. Epiphany Term, (3) Electrical Engineering, and (4) Haulage and Winding.

1908-1909. Michaelmas Term, (5) Transmission of Power, and (6) Pumping and Ventilation. Epiphany Term, (7) Metallurgy of Iron and Steel, and (8) Mining Machinery (mainly machinery used underground).

1909-1910. Michaelmas Term, (9) Machine Drawing, and (10) the Chemistry of Fuel. Epiphany Term, (11) Strength of Materials (with experimental illustrations), and (12) Experimental Mechanics.

Several colliery-owners have paid the fees (£1 10s. per annum) and railway-expenses of pupils attending the classes from their collieries. During the past year, the lectures of the Michaelmas Term on Mensuration were attended by 27 students, and the Chemistry of Fuel by 29 students, 22 of whom sat for examination and 16 passed: and during the Epiphany Term, the lectures on the Strength of Materials were attended by 22 students, and upon Experimental Mechanics by 22 students: 17 of these were examined and 11 passed. Certificates have been awarded to the following students, who have completed the three years' course:—Messrs. G. H. Bell, T. H. Mitchell and J. T. Pringle. The first and second prizes, for the session 1906-1907, have been divided between Messrs. Mark Halliday and Samuel Cadwallender, who gained the highest aggregate number of marks.

A Committee, consisting of Messrs. T. E. Forster, George May, J. H. Merivale, J. G. Weeks and the Secretary (Mr. M. Walton Brown), appointed to enquire into and report upon the decrease of the attendance at the Colliery Engineers Classes, reported that the apparent decrease in the number of students in recent years, arose from the poor quality of those attending in early years, and they were of opinion that the present students were fully capable of taking advantage of the lectures. Certain alterations in the syllabus of lectures, suggested by the Committee, were agreed to by the authorities of Armstrong College.

Supplementary volumes to *An Account of the Strata of Northumberland and Durham, as proved by Borings and Sinkings*, are in course of publication, a large number of sections having been received from members and other friends.

Exchanges of Transactions have been arranged, during the year, with the Rhodesia Scientific Association: the Mining and Geological Institute of India: the Comité Central des Houillères de France: and the Mysore Geological Department.

Mr. Thomas Douglas has been appointed, in succession to the late Mr. John Daglish, on the Council of Armstrong College, which was jointly founded in 1871 by the University of Durham and The North of England Institute of Mining and Mechanical Engineers. Mr. Thomas Emerson Forster, in conjunction with the President (Mr. John Herman Merivale), represents the Institute on the Council of the College.

Mr. George May continues to represent the Institute upon the Board of Directors of the Institute and Coal Trade Chambers Company, Limited.

Mr. J. Parke Channing was appointed to represent the Institute at the opening of the United Engineering Societies' Building, New York City, in April, 1907. Mr. R. H. Prior-Wandesforde represented the Institute at the Conference of the Royal Sanitary Institute, held at Dublin, in June, 1907. The Rev. G. M.

Capell represented the Institute at the Conference of the Corresponding Societies of the British Association for the Advancement of Science, held in Leicester, commencing on July 31st, 1907. The Geological Society of London will celebrate the centenary of their existence in September, 1907, and Prof. G. A. L. Lebour has been appointed to represent the Institute thereat, and will present an address.

Mr. J. H. Merivale has given evidence, as the representative of the Institute, before the Departmental Committee on the Miners' Eight Hours' Day.

The representatives of the Institute upon the Council of The Institution of Mining Engineers during the past year were as follows:—Messrs. Richard Donald Bain, Bennett Hooper Brough, Charles Spearman Carnes, William Cochran Carr, Frank Coulson, Thomas Douglas, Thomas Emerson Forster, John William Fryar, George Clementson Greenwell, Reginald Guthrie, Thomas Edgar Jobling, Austin Kirkup, Philip Kirkup, Charles Catterall Leach, Henry Louis, John Herman Merivale, John Morison, William Charles Mountain, Henry Palmer, Matthew William Parrington, Frank Robert Simpson, John Simpson, John Bell Simpson, John George Weeks and William Outterson Wood.

G. C. Greenwell gold, silver and bronze medals may be awarded annually for approved papers "recording the results of experience of interest in mining, and especially where deductions and practical suggestions are made by the writer for the avoidance of accidents in mines."

G. C. Greenwell silver medals have been awarded to Mr. W. E. Garforth for his paper upon "A New Apparatus for Rescue-work in Mines," and to Mr. G. A. Meyer for his paper upon "Rescue-apparatus and the Experiences gained therewith at the Courrières Collieries by the German Rescue-party;" and a bronze medal has been awarded to Mr. S. F. Walker for his papers upon "Earth in Collieries, with reference to the 'Special Rules for the Installation and Use of Electricity'" and "The Capacity-current and its Effect on Leakage-indications on Three-phase Electrical Power-service."

Prizes for books have been awarded to the writers of the following papers, communicated to the members during the year 1905-1906:—

"Improved Dampers for Coke-oven Flues." By Mr. William Archer, M.I.M.E.

"A Mechanical Coal-cutter in Queensland." By Mr. William Fryar.

"The Great Planes of Strain in the Absolute Roof of Mines." By Mr. Henry Wallace Gregory Halbaum, M.I.M.E.

"Corundum in Ontario, Canada: Its Occurrence, Working, Milling, Concentration and Preparation for the Market as an Abrasive." By Mr. David Gillespie Kerr, M.I.M.E.

"The Alumino-thermic Welding Process, and its Application to General Engineering." By Mr J. Stewart MacGregor.

"The Unwatering of the Achddu Colliery, with a Description of the Riedler Express Pump." By Mr. John Morris, M.I.M.E.

"Undersea Extensions at the Whitehaven Collieries, and the Driving of the Ladysmith Drift." By Mr. John Shanks, M.I.M.E.

"The Barton and Forcett Limestone-quarries." By Mr. Thomas Teasdale, M.I.M.E.

"Determination of the Specific Electrical Resistance of Coal, Ores, etc." By Mr. G. C. Wood.

At the recommendation of the Committee appointed to enquire into the treatment of coal-dust in collieries, the Council have made a maintenance-grant of £50 towards the cost of conducting further experiments on the inflammability of mixtures of coal-dust and air, together with £25 for apparatus, to Mr. Henry Widdas of Armstrong College. Dr. P. P. Bedson and Mr. Henry Widdas have read a paper, illustrated with numerous "Experiments illustrative of the Inflammability of Mixtures of Coal-dust and Air."

The rooms of the Institute have been used, during the year, by the Newcastle-upon-Tyne Association of Students of the Institution of Civil Engineers; the North of England Branch of the National Association of Colliery Managers; the North of England Gas Managers' Association; the North of England Volunteer Service Institution; and the Northumberland and Durham Provincial Committee of the Surveyors' Institution.

Members of the American Institute of Mining Engineers visited Newcastle-upon-Tyne on August 1st and 2nd, 1906, and visits to collieries, works, Bamburgh and Alnwick Castles and the Roman Wall were arranged for their entertainment. The thanks of the American Institute of Mining Engineers have been received for the courtesy shown to its members.

Excursion meetings were held at Bowburn colliery on September 10th, 1906; at Axwell Park colliery on December 5th, 1906; and at Wearmouth colliery on June 6th, 1907.

The thanks of the Institute have been sent to the owners of collieries, works, etc., visited during the year.

The papers printed in the *Transactions* during the year are as follows:—

"Experiments illustrative of the Inflammability of Mixtures of Coal-dust and Air." By Prof. P. Phillips Bedson, Hon. M.I.M.E., and Mr. Henry Widdas, M.I.M.E.

"Memoir of the late John Daglish." By Mr. M. Walton Brown, M.I.M.E.

"An Appliance for Automatically Stopping and Restarting Mine-wagons." By Prof. William Galloway, M.I.M.E.

"Ferro-concrete and its Applications." By Mr. T. J. Gueritte.

"Treatment of Dust in Mines, Aboveground and Belowground." By Mr. Richard Harle, M.I.M.E.

"Sliding-trough Conveyors." By Mr. M. Malplat.

"The Valuation of Mineral Properties." By Mr. Thomas Aloysius O'Donahue, M.I.M.E.

"Liquid Air and its Use in Rescue-apparatus." By Mr. Otto Simonis.

"Deposits in a Pit-fall at Tanfield Lea, Tantobie, County Durham." By Dr. J. A. Smythe.

"Bowburn Winning." By Mr. Addison Langhorne Steavenson, M.I.M.E.

"Electro-barograph for Mines." By Mr. B. H. Thwaite.

"Sinking through Magnesian Limestone and Yellow Sand by the Freezing-process at Dawdon Colliery, near Seaham Harbour, County Durham." By Mr. Ernest Seymour Wood, M.I.M.E.

A duplicate copy of Mr. William Smith's map, being "The Delineation of the Strata of England and Wales, part of Scotland, etc.," 1815, in a mahogany map-case, together with an empty mahogany map-case, has been presented to the Natural History Society of Northumberland, Durham and Newcastle-upon-Tyne.

The Council are pleased to report that the North-eastern Railway Company have granted reduced railway-fares to members

attending general or excursion meetings of the Institute; and they trust that this concession will lead to an increased attendance.

The Institution of Mining Engineers has now entered upon its nineteenth year, and the members are to be congratulated upon its continued success, and the increasing membership of the associated institutions. Meetings were held in Hanley in September, 1906, and in London in June, 1907.

ANNUAL REPORT OF THE FINANCE COMMITTEE.

The Finance Committee submit herewith a statement of accounts for the twelve months ending June 30th, 1907, duly audited.

The total receipts were £2,978 0s. 3d. Of this amount, £49 19s. was paid as subscriptions in advance, leaving £2,928 1s. 3d. as the ordinary income of the year, compared with £2,838 2s. 3d. in the previous year. The amount received for ordinary current-year subscriptions was £2,264 17s. and arrears £318 9s., as against £2,249 1s. and £287 16s. respectively in the year 1905-1906. *Transactions* sold realized £19 3s. 9d., as compared with £44 4s. 3d. in the earlier period; the sum received for interest on investments was £325 11s. 6d., the amount in the former year being £317 10s.

The expenditure was £2,622 13s. 3d., that for the previous year being £2,544 10s. 10d. The increase was due to expenditure in connection with the visit of the American Institute of Mining Engineers; the contribution of £75 towards the cost of experiments on coal-dust conducted at Armstrong College; and expenses incurred in the preparation of the Library catalogue. Increases are also shown in the charges for salaries and wages, heating and lighting, postages, etc., while there is a considerable decrease in the amount spent on the Wood Memorial Hall and also for printing and stationery, the latter in consequence of certain liabilities remaining unpaid at the close of the year, but carried forward and included in the balance-sheet.

The figures given above show that the income exceeded the expenditure by £355 7s., and adding to this the balance of £896 19s. 6d., a total balance of £1,252 6s. 6d. remains to the credit of the Institute. Of this amount, £499 17s. 6d. has been invested in the purchase of stock of the Newcastle and Gateshead Water Company, leaving the sum of £752 9s. to carry forward.

The names of 32 persons have been struck off the membership list in consequence of non-payment of subscriptions. The amount of subscriptions written off was £176 3s., of which £96 18s. was for sums due for the year 1906-1907, and £79 5s. for arrears. It is probable that a considerable proportion of these amounts will be recovered and credited in future years. Of the amounts previously written off, £68 16s. was recovered during the past year.

JOHN H. MERIVALE, *President.*

August 3rd, 1907.

LIABILITIES.

	£ s. d.	£ s. d.
Subscriptions paid in advance during the current year		54 3 0
The Institution of Mining Engineers		49 18 2
The George Clementson Greenwell prize fund	100 0 0	
Less, paid for medals	67 8 4	
		32 11 8
Printing, etc.		80 0 0
Capital		12,345 1 11

We, having examined the above account with the books, vouchers and securities relating thereto, certify that, in our opinion, it is correct. We have accepted the assets, books, pictures, maps, etc., and *Transactions* and other publications as valued by your officials.

JOHN G. BENSON AND SONS,
CHARTERED ACCOUNTANTS.

Newcastle-upon-Tyne,
August 3rd, 1907.

£12,561 14 9

ASSETS.

	£ s. d.	£ s. d.
Balance of account at bankers	711 4 7	
„ in Treasurer's hands	38 5 11	
Outstanding accounts due from authors for excerpts	2 18 6	
		752 9 0
Arrears of subscriptions		336 14 0
179 shares in the Institute and Coal-trade Chambers Company, Limited (at cost) ...	4,100 0 0	
Institute and Coal-trade Chambers Company, Limited (mortgage)	1,400 0 0	
£340 consolidated 5 per cent. preference stock of the Newcastle and Gateshead Water Company (at cost)	499 17 6	
		5,999 17 6
(Of the above amount, £1,640 2s. is due to life-subscriptions account.)		
Value of *Transactions* and other publications, as per stock account	322 14 3	
Books, pictures, maps, furniture and fittings	5,150 0 0	
		5,472 14 3

£12,561 14 9

DR. THE TREASURER IN ACCOUNT WITH THE NORTH OF ENGLAND FOR THE YEAR ENDING

June 30th, 1906.				£	s.	d.	£ s. d.
To balance of account at bankers				840	11	3	
,, ,, in Treasurer's hands				53	9	9	
,, outstanding accounts due from authors for excerpts				2	18	6	
							896 19 6
June 30th, 1907.							
To dividend of 7½ per cent. on 179 shares of £20 each in the Institute and Coal-trade Chambers Company, Limited, for the year ending June 30th, 1907 ...				268	10	0	
,, interest on mortgage of £1,400 with the Institute and Coal-trade Chambers Company, Limited				49	0	0	
,, dividend on £340 consolidated 5 per cent. preference stock of the Newcastle and Gateshead Water Company				8	1	6	
							325 11 6
To sales of *Transactions*							19 3 9
TO SUBSCRIPTIONS FOR 1906-1907 AS FOLLOWS:—							
762 members	@ £2 2s.			1,600	4	0	
85 associate members	@ £2 2s.			178	10	0	
159 associates	@ £1 5s.			198	15	0	
46 students	@ £1 5s.			57	10	0	
21 new members	@ £2 2s.			50	8	0	
5 new members, not yet elected ...	@ £2 2s.			10	10	0	
7 new associate members	@ £2 2s.			14	14	0	
1 new associate member, not yet elected	@ £2 2s.			2	2	0	
11 new associates	@ £1 5s.			13	15	0	
1 new associate, not yet elected ...	@ £1 5s.			1	5	0	
9 new students	@ £1 5s.			11	5	0	
				2,138	18	0	
33 subscribing firms	£113	8	0				
1 new subscribing firm	2	2	0				
1 new subscribing firm, not yet elected	2	2	0				
				117	12	0	
				2,256	10	0	
1 associate member, paid life-composition	31	0	0				
1 new member, paid life-composition	23	2	0				
				54	2	0	
				2,310	12	0	
Less, subscriptions for current year paid in advance at end of last year				45	15	0	
				2,264	17	0	
Add, arrears received				318	9	0	
				2,583	6	0	
Add, subscriptions paid in advance during current year				49	19	0	
							2,633 5 0
							£3,874 19 9

INSTITUTE OF MINING AND MECHANICAL ENGINEERS Cr.
JUNE 30TH, 1907.

June 30th, 1907.	£	s.	d.	£	s.	d.
By *Annual Report*	45	5	0			
„ banker's charges	22	1	6			
„ circulars and advance copies of papers	64	10	3			
„ cleaning Wood Memorial Hall, offices, etc.	30	1	11			
„ electric light	28	7	0			
„ expenses of meetings	95	3	3			
„ fuel	23	0	9			
„ furniture and repairs	27	0	10			
„ incidental expenses	5	6	1			
„ insurance	13	17	9			
„ investments	499	17	6			
„ library: binding £31 6 9						
„ „ books 26 9 9						
„ „ catalogue 23 0 0						
	80	16	6			
„ petty cash	2	9	4			
„ postages: circulars £42 3 6						
„ „ correspondence 20 15 2						
„ „ publications 23 8 8						
	86	7	4			
„ panels and portraits of Presidents	48	17	0			
„ prizes for papers	24	3	0			
„ rates and taxes	6	3	6			
„ rent of offices	24	9	8			
„ *Report of the Committee upon Mechanical Coal-cutting*	2	12	6			
„ reporting of general meetings	12	12	0			
„ salaries, wages, auditing, etc.	531	6	6			
„ stationery, etc.	26	15	5			
„ telephone rent	1	5	0			
„ travelling expenses	2	15	3			
„ Treatment of Coal-dust Committee	88	6	0			
„ water rate	3	17	8			
				1,797	8	6
By The Institution of Mining Engineers	1,326	17	4			
Less, amounts paid by authors for excerpts	1	15	1			
				1,325	2	3
				3,122	10	9
By balance of account at bankers	711	4	7			
„ „ in Treasurer's hands	38	5	11			
„ outstanding accounts due from authors for excerpts	2	18	6			
				752	9	0
				£3,874	19	9

DR. THE TREASURER OF THE NORTH OF ENGLAND INSTITUTE OF MINING

		£ s. d.	£ s. d.	£ s. d.
To 931 members.				
51 of whom have paid life-compositions.				
880				
2 not included in printed list.				
882	@ £2 2s.	... ...	1,852 4 0	
To 114 associate members.				
8 of whom have paid life-compositions				
106				
1 paid life-composition.		31 0 0		
105	@ £2 2s.	220 10 0		
			251 10 0	
To 190 associates,				
1 of whom has paid a life-composition.				
189	@ £1 5s.	... ..	236 5 0	
To 56 students.				
1 paid as a member.				
55	@ £1 5s.	... ..	68 15 0	
To 33 subscribing firms		... ...	113 8 0	
				2,522 2 0
To 24 new members	@ £2 2s.	50 8 0		
1 new member, paid a life-composition ...		23 2 0		
5 new members, not yet elected	@ £2 2s.	10 10 0		
30			84 0 0	
To 7 new associate members	@ £2 2s.	14 14 0		
1 new associate member, not yet elected		2 2 0		
8			16 16 0	
To 11 new associates	@ £1 5s.	13 15 0		
1 new associate, not yet elected	@ £1 5s.	1 5 0		
12			15 0 0	
To 9 new students	@ £1 5s.	... ...	11 5 0	
To 1 new subscribing firm		2 2 0		
1 new subscribing firm, not yet elected ...		2 2 0		
2			4 4 0	131 5 0
To arrears, as per balance sheet, 1905-1906		...	419 15 0	
Add, arrears considered irrecoverable, but since paid ...			68 16 0	488 11 0
				3,141 18 0
To subscriptions paid in advance		... ...	... ...	49 19 0
				£3,191 17 0

AND MECHANICAL ENGINEERS IN ACCOUNT WITH SUBSCRIPTIONS, 1906–1907. CR.

			PAID. £ s. d.	UNPAID. £ s. d.	STRUCK OFF LIST. £ s. d.
By 762	members, paid	@ £2 2s.	1,600 4 0	.....	.....
89	,, unpaid ...	@ £2 2s.	.....	186 18 0	...
5	,, excused payment	@ £2 2s.	.....	.....	10 10 0
5	,, dead	@ £2 2s.	.....	.....	10 10 0
21	,, struck off list	@ £2 2s.	.....	.....	44 2 0
882					
By 85	associate members, paid	@ £2 2s.	178 10 0	.....	.....
1	,, ,, paid a life-composition		31 0 0	.....	.. ...
12	,, ,, unpaid	@ £2 2s.	.....	25 4 0	.....
2	,, ,, excused	@ £2 2s.	.....	.....	4 4 0
6	,, ,, struck off list		... ..	.....	12 12 0
106					
By 159	associates, paid	@ £1 5s.	198 15 0	.....	.....
22	,, unpaid ...	@ £1 5s.	.....	27 10 0	.....
8	,, struck off list	@ £1 5s.	.....	.....	10 0 0
189					
By 46	students, paid	@ £1 5s.	57 10 0	.....	.....
5	,, unpaid ...	@ £1 5s.	.....	6 5 0	.....
1	,, excused payment	@ £1 5s.	.....	.....	1 5 0
3	,, struck off list...	@ £1 5s.	.....	.....	3 15 0
55					
By 33	subscribing firms, paid		113 8 0	.....	.....
By 24	new members, paid ...	@ £2 2s.	50 8 0	.....	.....
1	,, ,, paid a life-composition		23 2 0	.....	.....
5	,, ,, not yet elected	@ £2 2s.	10 10 0	.....	.....
30					
By 7	new associate members, paid	@ £2 2s.	14 14 0	.....	.....
1	,, ,, not yet elected	@ £2 2s.	2 2 0	.....	.....
8					
By 11	new associates, paid ...	@ £1 5s.	13 15 0	.....	.....
1	,, ,, not yet elected	@ £1 5s.	1 5 0	.....	.....
12					
By 9	new students, paid ...	@ £1 5s.	11 5 0	.....	.....
By 2	new subscribing firms, paid	@ £2 2s.	4 4 0	.....	.. ...
			2,310 12 0	245 17 0	96 18 0
By arrears	... ...		318 9 0	90 17 0	79 5 0
			2,629 1 0		
By subscriptions paid in advance	... ...		49 19 0	.....	.....
			2,679 0 0	336 14 0	176 3 0
					336 14 0
					2,679 0 0
					£3,191 17 0

LIST OF COMMITTEES APPOINTED BY THE COUNCIL, 1907-1908.

Finance Committee.

Mr. Frank Coulson.
Mr. T. Douglas.
Mr. T. E. Forster.
Mr. T. Y. Greener.
Mr. T. E. Jobling.
Mr. George May.
Mr. John Simpson.
Mr. J. B. Simpson.
Mr. J. G. Weeks.

Arrears Committee.

Mr. Frank Coulson.
Mr. T. Douglas.
Mr. T. E. Forster.
Mr. T. Y. Greener.
Mr. T. E. Jobling.
Mr. George May.
Mr. John Simpson.
Mr. J. B. Simpson.
Mr. J. G. Weeks.

Library Committee.

Mr. R. S. Anderson.
Mr. T. E. Forster.
Mr. J. P. Kirkup.
Mr. George May.
Mr. H. Palmer.
Mr. John Simpson.
Mr. J. G. Weeks.

Prizes Committee.

Mr. T. E. Forster.
Mr. C. C. Leach.
Mr. A. D. Nicholson.
Mr. H. Palmer.
Mr. F. R. Simpson.
Mr. John Simpson.
Mr. Simon Tate.

Borings and Sinkings Committee.

Mr. J. B. Atkinson.
Mr. R. Donald Bain.
Mr. W. C. Blackett.
Mr. Frank Coulson.
Mr. T. E. Forster.
Prof. G. A. Lebour.
Prof. H. Louis.
Mr. A. D. Nicholson.
Mr. R. F. Spence.

Treatment of Coal-dust in Collieries Committee.

Prof. P. Phillips Bedson.
Mr. W. C. Blackett.
Mr. W. Cochran Carr.
Mr. Samuel Hare.
Mr. Philip Kirkup.
Mr. H. Lawrence.
Mr. John Morison.
Mr. R. L. Weeks.
Mr. Henry Widdas.

Reference Committee for Papers to Read.

(a) Coal-mining.

Mr. W. C. Blackett.
Mr. C. S. Carnes.
Mr. Benjamin Dodd.
Mr. A. M. Hedley.
Mr. C. C. Leach.
Mr. George May.
Mr. H. Palmer.
Mr. John Simpson.
Mr. A. L. Steavenson.

(b) Metalliferous Mining.

Mr. R. Donald Bain.
Mr. A. M. Hedley.
Mr. J. H. Merivale.
Mr. A. D. Nicholson.
Mr. A. L. Steavenson.
Mr. C. H. Steavenson.

(c) Geological.

Mr. R. S. Anderson.
Mr. R. Donald Bain.
Mr. Samuel Hare.
Mr. T. E. Jobling.
Mr. J. H. Merivale.
Mr. John Simpson.

(d) Mechanical and Electrical Engineering.

Mr. W. C. Blackett.
Mr. J. P. Kirkup.
Mr. H. Lawrence.
Mr. C. C. Leach.
Mr. J. H. Merivale.
Mr. W. C. Mountain.
Mr. J. H. Nicholson.
Hon. C. A. Parsons.
Mr. A. L. Steavenson.

(e) Civil Engineering.

Mr. Benjamin Dodd.
Mr. T. E. Forster.
Mr. W. C. Mountain.
Mr. M. W. Parrington.
Mr. J. B. Simpson.
Mr. A. L. Steavenson.

(f) Chemical.

Prof. P. Phillips Bedson.
Mr. Benjamin Dodd.
Dr. G. P. Lishman.

N.B.—The President is *ex-officio* on all Committees.

OFFICERS, 1907-1908.

PAST-PRESIDENTS (*ex-officio*).

Sir LINDSAY WOOD, Bart., The Hermitage, Chester-le-Street.
Mr. JOHN BELL SIMPSON, Bradley Hall, Wylam, S.O., Northumberland.
Mr. ADDISON LANGHORNE STEAVENSON, Durham.
Mr. THOMAS DOUGLAS, The Garth, Darlington.
Mr. GEORGE MAY, The Harton Collieries, South Shields.
Mr. WILLIAM ARMSTRONG, Wingate, S.O., County Durham.
Mr. JOHN GEORGE WEEKS, Bedlington, S.O., Northumberland.
Mr. WILLIAM OUTTERSON WOOD, South Hetton, S.O., County Durham.
Mr. THOMAS WALTER BENSON, Collingwood Buildings, Collingwood Street, Newcastle-upon-Tyne.

PRESIDENT.

Mr. JOHN HERMAN MERIVALE, Togston Hall, Acklington, S.O., Northumberland.

VICE-PRESIDENTS.

Mr. RICHARD DONALD BAIN, H.M. Inspector of Mines, Durham.
Mr. WILLIAM CUTHBERT BLACKETT, Acorn Close, Sacriston, Durham.
Mr. FRANK COULSON, Shamrock House, Durham.
Mr. THOMAS EMERSON FORSTER, 3, Eldon Square, Newcastle-upon-Tyne.
Mr. HENRY PALMER, Medomsley, S.O., County Durham.
Mr. JOHN SIMPSON, Heworth Colliery, Felling, S.O., County Durham.

RETIRING VICE-PRESIDENTS (*ex-officio*).

Mr. THOMAS YOUNG GREENER, West Lodge, Crook, S.O., County Durham.
Mr. MATTHEW WILLIAM PARRINGTON, Wearmouth Colliery, Sunderland.

COUNCILLORS.

Mr. ROBERT SIMPSON ANDERSON, Benwell View, Bentinck Road, Newcastle-upon-Tyne.
Mr. JOHN BOLAND ATKINSON, H.M. Inspector of Mines, 2, Devonshire Terrace, Newcastle-upon-Tyne.
Mr. CHARLES SPEARMAN CARNES, Howlish Hall, Bishop Auckland.
Mr. BENJAMIN DODD, Bearpark Colliery, Durham.
Mr. SAMUEL HARE, Murton Colliery, *viâ* Sunderland.
Mr. ARTHUR MORTON HEDLEY, Blaydon Burn, Blaydon-upon-Tyne, S.O., County Durham.
Mr. THOMAS EDGAR JOBLING, Bebside, S.O., Northumberland.
Mr. JOHN PHILIP KIRKUP, Burnhope, Durham.
Mr. PHILIP KIRKUP, Leafield House, Birtley, S.O., County Durham.
Mr. HENRY LAWRENCE, 13, Devonshire Place, Newcastle-upon-Tyne.
Mr. CHARLES CATTERALL LEACH, Seghill Colliery, Seghill, Dudley, S.O., Northumberland.
Mr. ARTHUR DARLING NICHOLSON, H.M. Inspector of Mines, 2, Graingerville, Newcastle-upon-Tyne.
Mr. JOHN HODGSON NICHOLSON, Cowpen Colliery Office, Blyth.
Hon. CHARLES ALGERNON PARSONS, Heaton Works, Newcastle-upon-Tyne.
Mr. FRANK ROBERT SIMPSON, Hedgefield House, Blaydon-upon-Tyne, S.O., County Durham.
Mr. CHARLES HERBERT STEAVENSON, Redheugh Colliery, Gateshead-upon-Tyne.
Mr. SIMON TATE, Trimdon Grange Colliery, County Durham.
Mr. RICHARD LLEWELLYN WEEKS, Willington, S.O., County Durham.

TREASURER.

Mr. REGINALD GUTHRIE, Neville Hall, Newcastle-upon-Tyne.

SECRETARY.

Mr. MARTIN WALTON BROWN, Neville Hall, Newcastle-upon-Tyne.

AUDITORS.

Messrs. JOHN G. BENSON and SONS, Newcastle-upon-Tyne.

BANKERS.

Messrs. LAMBTON and COMPANY, Newcastle-upon-Tyne.

LIST OF MEMBERS,

AUGUST 3, 1907.

PATRONS.

His Grace the DUKE OF NORTHUMBERLAND.
The Most Honourable the MARQUESS OF LONDONDERRY.
The Right Honourable the EARL OF DURHAM.
The Right Honourable the EARL GREY.
The Right Honourable the EARL OF LONSDALE.
The Right Honourable the EARL OF WHARNCLIFFE.
The Right Reverend the LORD BISHOP OF DURHAM.
The Right Honourable LORD ALLENDALE
The Right Honourable LORD BARNARD.
The Right Honourable LORD RAVENSWORTH.
The Very Reverend the DEAN AND CHAPTER OF DURHAM.

HONORARY MEMBERS (Hon. M.I.M.E.).

* Honorary Members during term of office only.

	Date of Election.
1*JOHN BOLAND ATKINSON, H.M. Inspector of Mines, 2, Devonshire Terrace, Newcastle-upon-Tyne	Aug. 4, 1888
2*WILLIAM NICHOLAS ATKINSON, H.M. Inspector of Mines, Bridgend	Aug. 4, 1888
3*RICHARD DONALD BAIN, H.M. Inspector of Mines, Durham	Dec. 12, 1896
4*Prof. PETER PHILLIPS BEDSON, Armstrong College, Newcastle-upon-Tyne. *Transactions* sent to The Chief Librarian, Public Library, New Bridge Street, Newcastle-upon-Tyne ...	Feb. 10, 1883
5 THOMAS BELL, 16, Grosvenor Road, Scarborough	Dec. 12, 1896
6 JOSEPH DICKINSON, 3, South Bank, Sandy Lane, Pendleton, Manchester	Dec. 13, 1852
7 Prof. WILLIAM GARNETT, Education Office, Victoria Embankment, London, W.C.	Nov. 24, 1894
8*JOHN GERRARD, H.M. Inspector of Mines, Worsley, Manchester	June 11, 1892
9*FREDERICK AUGUSTUS GRAY, H.M. Inspector of Mines, 7, Victoria Square, Penarth	June 14, 1902
10*HENRY HALL, H.M. Inspector of Mines, Rainhill, S.O., Lancashire	March 4, 1876
11*HUGH JOHNSTONE, H.M. Inspector of Mines, Stafford ...	Oct. 13, 1906
12*Prof. GEORGE ALEXANDER LOUIS LEBOUR, Armstrong College, Newcastle-upon-Tyne. *Transactions* sent to Radcliffe House, Corbridge, S.O., Northumberland	Nov. 1, 1879
13*Prof. HENRY LOUIS, Armstrong College, Newcastle-upon-Tyne. *Transactions* sent to The Librarian, Armstrong College, Newcastle-upon-Tyne	Dec. 12, 1896
14*ROBERT McLAREN, H.M. Inspector of Mines, Craigmore, 77, Colinton Road, Edinburgh	Dec. 13, 1902
15*JOSEPH SAMUEL MARTIN, I.S.O., H.M. Inspector of Mines, The Vikings, 16, Durdham Park, Bristol	Aug. 4, 1888
16*JOHN MARTINE RONALDSON, H.M. Inspector of Mines, 44, Athole Gardens, Glasgow	Aug. 4, 1888
17*ARTHUR HENRY STOKES, H.M. Inspector of Mines, Greenhill, Derby	Aug. 4, 1888
18*Prof. HENRY STROUD, Armstrong College, Newcastle-upon-Tyne	Nov. 5, 1892

Date of Election.

19*JETHRO JUSTIMAN HARRIS TEALL, Director of the Geological Survey of the United Kingdom, 28, Jermyn Street, London, S.W. ... ... Aug. 3, 1901
20*WILLIAM WALKER, H.M. Inspector of Mines, Doncaster ... Oct. 14, 1905
21*Prof. ROBERT LUNAN WEIGHTON, Armstrong College, Newcastle-upon-Tyne. *Transactions*, etc., sent to 2, Park Villas, Gosforth, Newcastle-upon-Tyne ... ... April 2, 1898

MEMBERS (M.I.M.E.).

Marked * have paid life composition.

Date of Election and of Transfer

1 Abbott, Henry Arnold, H.M. Inspector of Mines, 1, Highbury, West Jesmond, Newcastle-upon-Tyne ... Feb. 13, 1904
2 Abel, Walter Robert, 8, Queens Gardens, Benton, Newcastle-upon-Tyne ... ... Dec. 8, 1906
3 Acutt, Sidney, The Barrett Gold-mining Company, Limited, Kaapoche Hoop, Transvaal ... ... Dec. 10, 1904
4 Adair, Hubert, Gillfoot, Egremont, S.O., Cumberland ... April 8, 1905
5 Adams, George Francis, Inspector of Mines in India, 6, Dacres Lane, Calcutta, India ... ... Aug. 5, 1905
6 Adams, Henry Hopper, Takapuna, Auckland, New Zealand April 10, 1897
7 Adams, Ormsby Gore, School of Mines, Thames, New Zealand ... ... Dec. 9, 1905
8 Adams, Phillip Francis Burnet, Surveyor-General for the Orange River Colony, Government Office, Bloemfontein, Orange River Colony, South Africa ... ... Oct. 12, 1901
9 Adamson, Thomas, Giridih, East Indian Railway, Bengal, India ... ... Feb. 10, 1894
10 Ainsworth, Herbert, P.O. Box 1553, Johannesburg, Transvaal ... ... Feb. 14, 1903
11 Ainsworth, John W., Bridgewater Offices, Walkden, Manchester ... ... Dec. 14, 1895
12 Alger, Charles Ernest, 160, Dock Street, Newport, Monmouthshire ... ... Aug. 1, 1903
13 Allan, John Frederick, C^ia de Rio Tinto, Limited, Calle de Valenzuela No. 4, Madrid, Spain ... ... A.M. Feb. 10, 1883 M. June 8, 1889
14 Allan, Philip, 1, Marlborough Gardens, Stanwix, Carlisle June 10, 1905
15 Allison, J. J. C., Woodland Collieries, Butterknowle, S.O., County Durham ... ... A.M. Feb 13, 1886 M. June 8, 1889
16 Andersen, Carl, Sandy, Lincoln County, Nevada, U.S.A. Oct. 8, 1904
17 Anderson, Robert Hay, Apartado Postal 866, Mexico, D.F. Aug. 4, 1894
18 Anderson, Robert Simpson, Benwell View, Bentinck Road, Newcastle-upon-Tyne (*Member of Council*) ... ... S. June 9, 1883 A.M. Aug. 4, 1888 M. Aug. 3, 1889
19 Andrews, Arthur, 10, Ashwood Terrace, Sunderland ... Aug. 2, 1902
20 Andrews, Edward William, 4, Ashwood Terrace, Sunderland ... ... Aug. 4, 1906
21*Angwin, Benjamin, St. Leonards, Bassett Road, Camborne, Cornwall ... ... Nov. 24, 1894
22 Appleby, Harry Walton, P.O. Box 1030, Johannesburg, Transvaal ... ... Oct. 8, 1898
23 Appleby, William Remsen, Minnesota School of Mines, The University of Minnesota, Minneapolis, Minnesota, U.S.A. April 14, 1894
24 Archer, Thomas, Mardale Parade, Gateshead-upon-Tyne July 2, 1872
25 Archer, William, Victoria Garesfield, Lintz Green, County Durham ... ... A. Aug. 6, 1892 M. Aug. 3, 1895
26 Armstrong, George Herbert Archibald, Castle View, Chester-le-Street ... ... April 8, 1905
27 Armstrong, Henry, Collingwood Buildings, Collingwood Street, Newcastle-upon-Tyne ... ... A.M. April 14, 1883 M. June 8, 1889
28 Armstrong, William, Wingate, S.O., County Durham (Past-President, *Member of Council*) ... ... S. April 7, 1867 M. Aug. 6, 1870

		Date of Election and of Transfer.
29	ASHMORE, GEORGE PERCY, 109, Lansdowne Place, Hove, Brighton	Feb. 13, 1897
30	ATHERTON, THOMAS WILLIAM TURNER, c o Miss Atherton, Children's Hospital, Chipping Norton	A.M. June 11, 1898 M. Dec. 10, 1898
31	ATHRON, HAROLD VIVIAN, Laburnum Cottage, Hindley, Wigan	Feb. 13, 1904
32	ATKINSON, JOHN BOLAND, H.M. Inspector of Mines, 2, Devonshire Terrace, Newcastle-upon-Tyne (*Member of Council*)	Oct. 11, 1902
33	ATKINSON, R. HUGH M. BUDDLE	April 10, 1897
34	ATTWOOD, ALFRED LIONEL, Remolinos, por Pedrola, Provincia de Zaragoza, Spain	Aug. 5, 1905
35	AUBREY, RICHARD CHARLES, Belgrave, Trent Valley Road, Lichfield	Feb. 5, 1870
36	AXTELL, THOMAS, 5, Sea View, Ryhope, Sunderland ...	Oct. 8, 1904
37	BAILES, THOMAS, Jesmond Gardens, Newcastle-upon-Tyne	Oct. 7, 1858
38	BAILEY, EDWARD TRENHOLM, c o Royal Colonial Institute, Northumberland Avenue, London, W.C.	A.M. June 13, 1896 M. June 12, 1897
39	BAIN, HARRY FOSTER, Champaign, Illinois, U.S.A. ...	Dec. 10, 1898
40	BAIN, RICHARD DONALD, H.M. Inspector of Mines, Durham (VICE-PRESIDENT, *Member of Council*)	S. March 1, 1873 M. Aug. 5, 1876
41	BAINERIDGE, EMERSON, 4, Whitehall Court, London, S.W.	S. Dec. 3, 1863 M. Aug. 1, 1868
42	BAINBRIDGE, EMERSON MUSCHAMP, Bentinck House, Kirkby-in-Ashfield, Nottingham	Feb. 8, 1902
43	BALDWIN, IVO WILLIAM, Oakleigh, Ruardean, Mitcheldean, S.O., Gloucestershire	Feb. 10, 1900
44	BARBER, GEORGE MARRIOTT, 42, Clapham Road, Bedford ...	April 28, 1900
45	BARNARD, ROBERT, Kuardih, Kalipahari P.O., Asansol, Bengal, India	Dec. 11, 1897
46	BARRASS, MATTHEW, Wheatley Hill Colliery Office, Thornley, S.O., County Durham	S. Feb. 9, 1884 A. Aug. 1, 1891 M. Dec. 8, 1900
47	BARRETT, CHARLES ROLLO, Whitehill Hall, Chester-le-Street	S. Nov. 7, 1874 A.M. Aug. 7, 1880 M. Dec. 11, 1886
48	BARROW, WILLIAM, Seaton Burn Colliery, Dudley, S.O., Northumberland	Feb. 8, 1902
49*	BARTHOLOMEW, CHARLES WILLIAM, Blakesley Hall, near Towcester	Dec. 4, 1875
50	BARTON, HENRY, Central Bank Chambers, Leeds	Oct. 13, 1900
51	BATES, MATTHEW JOHN, Highbury, Stocksfield, S.O., Northumberland	Feb. 11, 1905
52	BATES, SIDNEY, The Grange, Prudhoe, Ovingham, S.O., Northumberland	A. Feb. 8, 1890 M. June 8, 1895
53	BATES, THOMAS L., Station Street, Waratah, New South Wales, Australia	Feb. 12, 1898
54	BATESON, WALTER REMINGTON, c o Penny and Duncan, Huanuni, Oruro, Bolivia, South America ...	Feb. 11, 1905
55	BATEY, JOHN, St. Edmunds, Coleford, Bath	Dec. 5, 1868
56	BATEY, JOHN WRIGHT, Elmfield, Wylam, S.O., Northumberland	Feb 9, 1901
57	BAWDEN, WILLIAM, Pillar House, Keswick	Feb. 10, 1906
58	BAYLISS, ERNEST JOHN, Inglenook, Beedell Avenue, Westcliff-on-Sea, Southend-on-Sea	April 13, 1901
59	BEARD, JAMES THOM, 640, Clay Avenue, Scranton, Pennsylvania, U.S.A.	Feb. 14, 1903
60	BEKENN, ALEXANDER RICHARD, Dundee Coal Company, Limited, Talana, Natal, South Africa	Feb. 9, 1907
61	BELL, JOSEPH FENWICK, Orchard House, North Biddick, Washington, S.O., County Durham	April 12, 1902
62	BELL, REGINALD, Field House, Western Hill, Durham ...	Dec. 13, 1902
63	BELL, WALTER, c o Pyman, Bell and Company, Hull ...	S. Oct. 8, 1889 M. Feb. 10, 1894

		Date of Election and of Transfer.
64	BELL, WILLIAM RALPH, Wearmouth Colliery, Sunderland	A. Oct. 13, 1894 M. Dec. 12, 1903
65	BENNETT, ALFRED HENRY, Bedminster, Easton, Kingswood and Parkfield Collieries, Limited, Easton Colliery, Bristol	A.M. April 10, 1886 M. June 8, 1889
66	BENNETT, HENRY, No. 5, Calle Sauz, La Minas de Rio Tinto, Provincia de Huelva, Spain	Dec. 9, 1899
67	BENSON, THOMAS WALTER, Collingwood Buildings, Collingwood Street, Newcastle-upon-Tyne (PAST-PRESIDENT, *Member of Council*)	Aug. 2, 1866
68	BERKLEY, CUTHBERT, Highfield House, Durham	Aug. 21, 1852
69	BERKLEY, RICHARD WILLIAM, Marley Hill, Swalwell, S.O., County Durham	S. Feb. 14, 1874 A.M. Aug. 7, 1880 M. June 8, 1889
70	BIGG-WITHER, HARRIS, The Mount, Gathurst, Wigan ...	Jan. 19, 1895
71	BIGGE, DENYS LEIGHTON SELBY, 27, Mosley Street, Newcastle-upon-Tyne	June 10, 1903
72	BIGLAND, HUBERT HALLAM, The Stones, Whitley Bay, S.O., Northumberland	Dec. 14, 1901
73	BIGLAND, JOHN, Henknowle, Bishop Auckland	June 3, 1857
74	BLACKETT, WILLIAM CUTHBERT, Acorn Close, Sacriston, Durham (VICE-PRESIDENT, *Member of Council*) ...	S. Nov. 4, 1876 A.M. Aug. 1, 1885 M. June 8, 1889
75	BLAIKLOCK, THOMAS HENDERSON, Bebside Colliery, Bebside, S.O., Northumberland	April 13, 1901
76	BONNIWELL, PERCIVAL ORMOND, Cardeeth, 32, Rylett Crescent, Ravenscourt Park, London, W.	Dec. 12, 1903
77	BORLASE, WILLIAM HENRY, Greenside Lodge, Glenridding, Penrith	Aug. 4, 1894
78	BOWMAN, FRANCIS, Ouston Colliery Office, Chester-le-Street	A. June 8, 1895 M. Feb. 13, 1904
79*	BRACKEN, THOMAS WILSON, 40, Grey Street, Newcastle-upon-Tyne	Oct. 14, 1899
80	BRADFORD, GEORGE, Milbanke, Darlington	Oct. 11, 1890
81	BRAIDFORD, WILLIAM, Jun., South Garesfield Colliery, Lintz Green, County Durham	June 14, 1902
82	BRAMWELL, HUGH, Great Western Colliery, near Pontypridd	S. Oct. 4, 1879 A.M. Aug. 6, 1887 M. Aug. 3, 1889
83	BRASCHI, VICTOR MANUEL, Cadena No. 2, Apartado 830, City of Mexico, Mexico	A.M. Feb. 12, 1898 M. Aug. 6, 1898
84	BREAKELL, JOHN E., 69, Ifield Road, South Kensington, London, S.W.	April 25, 1896
85*	BRINELL, JOHAN AUGUST, Jernkontoret, Stockholm, Sweden	June 9, 1900
86	BROAD, WALLACE, c o Shanghai Club, Shanghai, China ...	April 28, 1900
87	BRODIGAN, CHARLES BERNARD, P.O. Box 3, Brakpan, Transvaal	Oct. 13, 1906
88	BROMLY, ALFRED HAMMOND, Tasco, Guerrero, Mexico ...	Nov. 24, 1894
89	BROOME, GEORGE HERBERT, Westport, New Zealand ...	Oct. 9, 1897
90*	BROUGH, BENNETT HOOPER, 28, Victoria Street, London, S.W.	A.M. Dec. 10, 1887 M. June 8, 1889
91	BROUGH, THOMAS, New Seaham Colliery, Sunderland ...	S. Feb. 1, 1873 A.M. Aug. 2, 1879 M. June 8, 1889
92	BROWN, DOUGLAS PHILIP, The Old House, Sowerby, Thirsk	June 11, 1898
93	BROWN, MARTIN WALTON, 10, Lambton Road, Newcastle-upon-Tyne (SECRETARY, *Member of Council*)	S. Oct. 7, 1871 M. Aug. 3, 1878
94	BROWN, RICHARD HENRY, 32, Kent Street, Halifax, Nova Scotia	Feb. 9, 1901
95	BROWN, ROBERT OUGHTON, Elswick Collieries, Newcastle-upon-Tyne	S. Oct. 8, 1892 A. Aug. 3, 1895 M. Oct. 12, 1901
96	BROWN, THOMAS FORSTER, Springfort, Stoke Bishop, Bristol	Aug. 1, 1861

		Date of Election and of Transfer.
97	Brown, W. Forster, Cefn Coed, Malpas, Newport, Monmouthshire	S. Aug. 6, 1887 M. Aug. 5, 1893
98	Browne, Robert John, Jharia, E.I.R., Bengal, India ...	Feb. 10, 1906
99	Bruce, John, Port Mulgrave, Hinderwell, S.O., Yorkshire	S. Feb. 14, 1874 A.M. Aug. 7, 1880 M. June 8, 1889
100	Bryham, William, Bank House, Wigan	Dec. 8, 1900
101	Buckle, Christopher Ernest, 19, Nightingale Road, Southsea	Feb. 10, 1900
102	Bull, Henry Matthews, Bengal Coal Company, Limited, Rayhara, E. I. Railway, Palaman District, India ...	April 9, 1904
103	Bulman, Edward Hemsley, The North Randfontein Gold-mining Company, Randfontein, Transvaal	Feb. 13, 1892
104	Bulman, Harrison Francis, Leazes Hall, Burnopfield, S.O., County Durham	S. May 2, 1874 A.M. Aug. 6, 1881 M. June 8, 1889
105	Bunning, Charles Ziethen, c/o The British Consular Agent, Panderma, Constantinople, Turkey	S. Dec. 6, 1873 A.M. Aug. 5, 1882 M. Oct. 8, 1887
106*	Burls, Herbert Thomas, 11, Foulis Terrace, Onslow Gardens, London, S.W.	Feb. 9, 1889
107*	Burn, Frank Hawthorn, 9, Sandhill, Newcastle-upon-Tyne. Transactions sent to Pattishall House, Towcester	S. Feb. 9, 1889 A. Aug. 4, 1894 M. Aug. 3, 1895
108	Burne, Cecil Alfred, Ranelagh Cottage, High Wycombe	S. Aug. 4, 1894 M. Aug. 3, 1901
109	Burnett, Cuthbert, Grange Iron Works, Durham ...	June 8, 1895
110*	Burns, David, Vallum View, Burgh Road, Carlisle ...	May 5, 1877
111	Burton, George Augustus, Liverton Grange, Loftus, S.O., Yorkshire	Dec. 9, 1905
112	Burton, Joseph James, Rosecroft, Nunthorpe, S.O., Yorkshire	April 12, 1902
113	Butt, Thomas Philip Edward, Randfontein Estates, Randfontein, Transvaal	Dec. 11, 1897
114	Butters, Charles, 220, Crocker Building, San Francisco, California, U.S.A.	Feb. 10, 1894
115	Carey, Gaspard Robert de Mussenden	Oct. 12, 1901
116	Carey, Joseph MacLeod, H.M. Inspector of Mines, Thornlea, Liberton, Edinburgh	April 4, 1903
117	Carnegie, Alfred Quintin, 31, Manor House Road, Newcastle-upon-Tyne	Oct. 11, 1902
118	Carnes, Charles Spearman, Howlish Hall, Bishop Auckland (*Member of Council*)	Aug. 1, 1891
119	Carroll, James, Brilliant and St. George Gold-mine, Charters Towers, Queensland, Australia	Dec. 10, 1898
120	Carroll, Miles T., Tananarive, Madagascar	Feb. 10, 1906
121	Casebourne, Ambrose Cubitt, 3, St. Nicholas' Buildings, Newcastle-upon-Tyne	June 9, 1906
122	Casebourne, Samuel Ward Jackson, Cleveland Terrace, Darlington	Dec. 10, 1904
123	Casson, William Walter, St. Bees, S.O., Cumberland ...	Aug. 5, 1905
124	Chambers, Arthur Leo, c/o The Messina Transvaal Development Company, Grenfell Camp, Pietersburg, Transvaal	Feb. 8, 1902
125	Chambers, J. S., 5, Jorkovskaja, St. Petersburg, Russia	Oct. 10, 1896
126	Chambers, R. E., The Nova Scotia Steel Company, Limited, Bell Island, Newfoundland	June 9, 1900
127	Channing, J. Parke, 11, Broadway, New York City, U.S.A.	April 25, 1896
128*	Chappel, Walter Richard Haighton, Ipok, Perak, Federated Malay States	Feb. 14, 1903
129	Charleton, Arthur George, 5, Avonmore Road, Kensington, London, W.	Aug. 6, 1892

		Date of Election and of Transfer.
130	CHARLTON, WILLIAM, Guisborough	Feb. 12, 1898
131	CHARLTON, WILLIAM JOHN, Ashington Colliery, Morpeth	April 25, 1896
132	CHEESMAN, EDWARD TAYLOR. Claravale Colliery, Ryton, S.O., County Durham	A. Aug. 2, 1890 M. Aug. 6, 1892
133	CHEESMAN, HERBERT. Hartlepool	Aug. 6, 1892
134	CHEESMAN, ISAAC TAYLOR, Throckley Colliery, Newburn, S.O., Northumberland	Feb. 1, 1873
135	CHEESMAN, NICHOLAS, Blucher Pit, Newburn, S.O., Northumberland	Dec. 8, 1900
136	CHESTER, EDWARD DESCOT, c/o Alf. Ewing, 36, Camomile Street, London, E.C.	Aug. 3, 1901
137	CHICKEN, BOURN RUSSELL, 42, Sunbury Avenue, Jesmond, Newcastle-upon-Tyne	Dec. 12, 1903
138	CHILDE, HENRY SLADE, 59, Westgate, Wakefield	A.M. Feb. 12, 1887 M. Aug. 3, 1889
139	CLAGHORN, CLARENCE R., Northwestern Improvement Company, Headquarters Building, Tacoma, Washington, U.S.A.	Aug. 5, 1899
140	CLARK, HENRY, Inglenook, Norton, Stockton-upon-Tees ...	April 8, 1899
141	CLARK, ROBERT, Rothalie, Fife Road, Darlington	Feb. 15, 1896
142	CLARK. ROBERT BLENKINSOP. Springwell Colliery, Gateshead-upon-Tyne	S. May 3, 1873 M. Aug. 4, 1877
143	CLARK, WILLIAM HENRY, 108, Cantonment, Kamptee, C.P., India	April 28, 1900
144	CLAUDET, ARTHUR CROZIER, 6 and 7, Coleman Street, London, E.C.	Aug. 3, 1895
145	CLIFFORD, WILLIAM, Jeannette, Pennsylvania, U.S.A. ...	Feb. 9, 1895
146	CLOUGH. JAMES. Bomarsund House, Bomarsund, Bedlington, S.O., Northumberland	S. April 5, 1873 A.M. Aug. 3, 1878 M. June 8, 1889
147	COCHRANE. BRODIE, Low Gosforth House, Newcastle-upon-Tyne	Dec. 6, 1866
148	COCKBURN, EVAN, Waldridge Colliery, Chester-le-Street	A. Aug. 5, 1893 M. Dec. 8, 1906
149	COLLEY, JOHN, Indwe Railway, Collieries and Land Company, Limited, P.O. Box 4, Indwe, Cape Colony, South Africa	Feb. 9, 1901
150*	COLLINS, HUGH BROWN, Auchinbothie Estate Office, Kilmacolm, S.O., Renfrewshire	April 14, 1894
151	COLLINS, VICTOR BUYERS, Lewis Street, Islington, *via* Newcastle, New South Wales, Australia	June 11, 1904
152	COLQUHOUN, THOMAS GRANT, The Durban Navigation Collieries, Limited, Dannhauser, Natal, South Africa	Dec. 14, 1898
153	COMMANS, ROBERT EDDEN, 6, Queen Street Place, London, E.C.	Nov. 24, 1894
154	COMSTOCK, CHARLES WORTHINGTON. Boston Building Denver, Colorado. U.S.A.	June 10, 1905
155	COOK. JOSEPH Washington Iron Works, Washington. S.O., County Durham	May 8, 1869
156	COOK, JOSEPH, Jun., Washington Iron Works, Washington, S.O., County Durham	Oct. 9, 1897
157	COOK, JAMES FALSHAW, Washington Iron Works, Washington, S.O., County Durham	Feb. 12, 1898
158	COOK, JOHN WATSON, Binchester Hall, Bishop Auckland...	Oct. 14, 1893
159	COOKE, HENRY MOORE ANNESLEY, The Ooregum Gold-mining Company of India, Limited, Oorgaum, Province of Mysore, India	Dec. 12, 1896
160*	COPPEE, EVENCE, Avenue Louise, 211, Brussels, Belgium ...	Feb. 9, 1907
161	CORBETT, VINCENT, Blackett Colliery, Haltwhistle, S.O., Northumberland	A. June 11, 1898 M. Feb. 13, 1904
162	CORBETT. VINCENT CHARLES STUART WORTLEY, Chilton Moor, Fence Houses	Sept. 3, 1870
163	CORLETT, GEORGE STEPHEN. Wigan	Dec. 12, 1891

		Date of Election and of Transfer.
164	CORNING, CHRISTOPHER ROBERT, 36, Wall Street, New York City, U.S.A.	June 14, 1902
165	COSTE, EUGENE, 34, Madison Avenue, Toronto, Ontario, Canada	June 9, 1900
166	COULSON, FRANK. Shamrock House, Durham (VICE-PRESIDENT, *Member of Council*)	S. Aug. 1, 1868 M. Aug. 2, 1873
167	COUVES, HARRY AUGUSTUS, 116, Shortridge Terrace, Jesmond, Newcastle-upon-Tyne	Feb. 10, 1906
168	COWPER-COLES, SHERARD OSBORN, Grosvenor Mansions, Victoria Street, Westminster, London, S.W.	Dec. 9, 1899
169	COX, JOHN H., 10, St. George's Square, Sunderland	Feb. 6, 1875
170	CRASTER, WALTER SPENCER, P.O. Box 216, Kopje, Salisbury, Rhodesia, South Africa	Dec. 8, 1900
171	CRAVEN, ROBERT HENRY, The Libiola Copper-mining Company, Limited, Sestri Levante, Italy	Feb. 11, 1905
172	CRAWFORD, JAMES MILL, Fairlawn, Leasingthorne, Bishop Auckland	Feb. 14, 1903
173	CROFTON, CHARLES, 17, Albany Gardens, Whitley Bay, S.O., Northumberland	Oct. 11, 1902
174	CROOKSTON, ANDREW WHITE, 188, St. Vincent Street, Glasgow	Dec. 14, 1895
175	CROSBY, ARTHUR, Douglas Colliery, Limited, Balmoral, Transvaal	A.M. Aug. 7, 1897 M. April 12, 1902
176	CROSS, WILLIAM HASLAM, 77, King Street, Manchester ...	Feb. 8, 1902
177	CRUZ Y DIAZ, EMILIANO DE LA, Calle de Balmes, 88, Barcelona, Spain	June 14, 1902
178	CUNNINGHAM, JOHN ALLAN, P.O. Box 59, Dundee, Natal, South Africa	Dec. 8, 1906
179	CURRIE, WALTER, P.O. Box 220, Bulawayo, Rhodesia, South Africa	April 25, 1896
180	CURRY, MICHAEL, Cornsay Colliery, Durham	Aug. 6, 1898
181	CUTTEN, WILLIAM HENRY, Billiter Square Buildings, London, E.C.	Aug. 5, 1899
182	DAGGAR HENRY JAMES, The Associated Gold-mines of Western Australia, Limited, Kalgoorlie, Western Australia	Oct. 12, 1901
183	DAGLISH, WILLIAM CHARLTON, Littleburn Colliery, near Durham	Dec. 12, 1896
184	DAKERS, WILLIAM ROBSON, Tudhoe Colliery, Spennymoor	A.M. Oct. 14, 1882 M. Aug. 3, 1889
185	DAN, TAKUMA, Mitsui Mining Company, 1, Suruga-cho, Nihonbashi-ku, Tokyo, Japan	April 14, 1894
186	DANIEL, PETER FRANCIS, Greymouth, New Zealand ...	April 8, 1893
187	DANKS, ANDREW, Glendale, Normandien, Post Newcastle, Natal, South Africa	Aug. 3, 1901
188	DARLING, FENWICK, Eldon Colliery, Eldon, Bishop Auckland	Nov. 6, 1875
189	DARLINGTON, JAMES, Black Park Colliery, Ruabon	S. Nov. 7, 1874 M. Aug. 4, 1877
190	DAVEY, GEORGE, 34, Carlton Vale, Maida Vale, London, W.	June 10, 1893
191	DAVIDSON, ALLAN ARTHUR, c/o F. F. Fuller, 138, Salisbury House, London, E.C.	April 13, 1907
192	DAVIES, DAVID, Cowell House, Llanelly	Dec. 9, 1899
193	DAVIES, WILLIAM STEPHEN, The Poplars, Mountain Ash ..	Feb. 14, 1903
194	DAVIS, CHARLES HENRY, 99, Cedar Street, New York City, U.S.A.	Oct. 13, 1900
195	DAW, ALBERT WILLIAM, 11, Queen Victoria Street, London, E.C.	June 12, 1897
196	DAW, JOHN W., Walreddon Manor, Tavistock ...	Dec. 14, 1895
197	DEAN, HARRY, Eastbourne Gardens, Whitley Bay, S.O., Northumberland	June 10, 1905
198	DEAN, JOHN, The Wigan Coal and Iron Company, Limited, Wigan	Feb. 13, 1904
199	DEAN, SAMUEL, Round House Colliery, Whelley, Wigan ...	Oct. 13, 1906

		Date of Election and of Transfer.
200	DEES, JAMES GIBSON, Floraville. Whitehaven	Oct. 13, 1883
201	DENNY, GEORGE A., 564, Salisbury House, London, E.C. ...	Dec. 8, 1894
202	DICK, WILLIAM, 190, Palmerston House, Old Broad Street, London, E.C.	April 13, 1907
203	DICKINSON, ARTHUR, Warham Road, South Croydon, Surrey	April 14, 1894
204	DIETZSCH, FERDINAND, 652-655, Salisbury House, London Wall, London, E.C.	Aug. 5, 1899
205*	DINGWALL, WILLIAM BURLISTON-ABIGAIL, Apartado 113, Matehuala, San Luis Potosi, Mexico	Aug. 4, 1900
206	DITMAS, FRANCIS IVAN LESLIE, Chindwara, Central Provinces, India	A. June 11, 1898 M. June 14, 1902
207	DIVES, ROBERT, *Industries* Offices, Saccharine Buildings, Railway Street, Durban, Natal, South Africa	Feb. 8, 1902
208	DIXON, DAVID WATSON, Lumpsey Mines. Brotton. S.O., Yorkshire	Nov. 2, 1872
209	DIXON, GEORGE, c/o Bird and Company, 100-101, Clive Street, Calcutta, India	S. June 13, 1896 A. Aug 6, 1904 M. Dec. 8, 1906
210	DIXON, JONATHAN, Westport Coal Company, Limited, Denniston. New Zealand	Oct. 13, 1894
211	DIXON, JOSEPH ARMSTRONG, Shilbottle Colliery, Lesbury, S.O., Northumberland	Dec. 14, 1901
212*	DIXON, JAMES STEDMAN, Fairleigh, Bothwell, Glasgow ...	Aug. 3, 1878
213	DIXON, ROBERT, Sankey Wire Mills and Ropeworks, Warrington	June 5, 1875
214	DIXON, WILLIAM, Cleator, S.O., Cumberland	April 10, 1897
215	DOBB, THOMAS GILBERT, Brick House, Westleigh, Leigh ...	Dec. 8, 1894
216	DOBBS, JOSEPH, Jarrow Colliery, Castlecomer, S.O., County Kilkenny	April 14, 1894
217	DODD, BENJAMIN, Bearpark Colliery, Durham (*Member of Council*)	S. May 3, 1866 M. Aug. 1, 1868
218	DODD, MICHAEL, Rand Club, Johannesburg, Transvaal ...	S. Dec. 4, 1875 A.M. Aug. 7, 1880 M. June 8, 1889
219	DOISE, SOSTHENES, Chaton (Seine-et-Oise), France ...	June 14, 1902
220	DONALD, WILLIAM E., Rhodesia Broken Hill, North Rhodesia, South Africa	Oct. 14, 1905
221*	DONKIN, WILLIAM, Mines Department, Macequece, Portuguese East Africa	S. Sept. 2, 1876 A.M. Aug. 1, 1885 M. June 8, 1889
222	DORMAND, RALPH BROWN, Cambois House, Cambois, Blyth	A. Dec. 9, 1893 M. Aug. 3, 1901
223	DOUGLAS, ARTHUR STANLEY, Low Beechburn Colliery Office, Crook, S.O., County Durham	Feb. 13, 1904
224*	DOUGLAS, CHARLES PRATTMAN, Thornbeck Hill. Carmel Road. Darlington	March 6, 1869
225	DOUGLAS, JAMES, 99, John Street, New York City, U.S.A.	Oct. 14, 1899
226	DOUGLAS, MATTHEW HECKELS, Usworth Colliery. Washington, S.O., County Durham	A.M. Aug. 2, 1879 M. Aug. 3, 1889
227	DOUGLAS, THOMAS. The Garth. Darlington (PAST-PRESIDENT. *Member of Council*)	Aug. 21, 1852
228	DRAPER, WILLIAM, Silksworth Colliery. Sunderland ...	A. Dec. 14, 1889 M. Dec. 12, 1903
229	DUNKERTON, ERNEST CHARLES, 97, Holly Avenue, Newcastle-upon-Tyne	Feb. 9, 1907
230	EASTLAKE, ARTHUR WILLIAM, Grosmont, Palace Road, Streatham Hill, London, S.W.	June 11, 1892
231	EDE, HENRY EDWARD, Caherdaniel, Waterville, S.O., County Kerry...	July 14, 1896
232	EDEN, CHARLES HAMILTON, Glyn-Dderwen, Blackpill, S.O., Glamorgan	June 14, 1890
233	EDGE, FREDERIC JAMES, 124, St. George's Terrace, Newcastle-upon-Tyne	Feb. 10, 1906

Date of Election and of Transfer.

234 Edwards, Edward, Maindy Pit, Ocean Collieries, Ton Pentre, Pentre, Pontypridd ... ... Feb. 9, 1895
235 Edwards, Herbert Francis, 104, Stanwell Road, Penarth Oct. 12, 1901
236 Edwards, Owain Tudor, Mohpani Mines, C.P., India ... Aug. 4, 1906
237 Elief, Francis Constant André Benoni Elie du, Compagnie Lyonnaise de Madagascar, à Ambositra, Madagascar ... ... Aug. 3, 1901
238*Elsdon, Robert William Barrow ... ... April 13, 1901
239 Eltringham, George, Eltringham Colliery, Prudhoe, A. Dec. 8, 1894
Ovingham, S.O., Northumberland ... ... M. Aug. 2, 1902
240 Elwin, Thomas Lee, Brandon Colliery, S.O., County Durham ... ... Oct. 13, 1888
241 Embleton, Henry Cawood, Central Bank Chambers, Leeds ... ... April 14, 1894
242 English, John, Broomfield, Chopwell, Ebchester, S.O., County Durham ... ... Dec. 9, 1899
243 Epton, William Martin, Government Inspector of Machinery, Mines Department, Winchester House, Johannesburg, Transvaal ... ... Oct. 12, 1895
244 Esmarch, Cecil August, 13, Westgate Road, Newcastle-upon-Tyne ... ... April 9, 1904
245 Etherington, John, 39A, King William Street, London Bridge, London, E.C. ... ... Dec. 9, 1893
246 Evans, Lewis, New Modderfontein Gold-mining Company, Limited, Mine Office, Benoni, Transvaal... ... ... Oct. 14, 1893
247 Everard, John Breedon, 6, Millstone Lane, Leicester March 6, 1869

248 Fairley, James, Craghead and Holmside Collieries, Chester-le-Street ... ... A.M. Aug. 7, 1880
M. Aug. 3, 1889
249 Fangen, Stener August, Kroken No. 7, Bergen, Norway April 9, 1904
250 Favell, John Milnes, Sudan Survey Department, Khartoum, Sudan, Egypt ... ... Aug. 5, 1905
251 Fawcett, Edward Stoker, Battle Hill House, Walker, A. June 11, 1892
Newcastle-upon-Tyne ... ... M. Aug. 6, 1904
252 Felton, John Robinson, West Stanley Colliery, Stanley, S. June 8, 1901
S.O., County Durham ... ... M. June 10, 1905
253*Fenwick, Barnabas, 37, Osborne Road, Newcastle-upon-Tyne ... ... Aug. 2, 1866
254 Fergie, Charles, P.O. Box 64, Sydney, Nova Scotia ... Dec. 9, 1893
255 Ferguson, David, 140, Hyndland Drive, Kelvinside, A.M. Dec. 8, 1883
Glasgow ... ... M. Aug. 3, 1889
256 Ferguson, James, P.O. Box 98, Johannesburg, Transvaal Dec. 12, 1896
257 Field, Edwin Richard, Daylesford, Victoria, Australia ... April 28, 1900
258 Fieuzet, Eugène, 4, rue Saint Blaise, Bagnères de Bigorre, Hautes Pyrénées, France ... ... Dec. 14, 1901
259 Figari, Alberto, Apartado 405, Lima, Peru, South America ... ... April 25, 1896
260 Fishback, Martin, Guaranty Trust Building, El Paso, Texas, U.S.A. ... ... April 12, 1902
261 Fisher, Edward Robert, Blaina Lodge, Llandebie, S.O., A.M. Aug. 2, 1884
Carmarthenshire ... ... M. Aug. 3, 1889
262 Fisher Henry Herbert, Calle Once de Setiembre, 1912, Belgrano, near Buenos Aires, Argentine Republic, South America ... ... Oct. 8, 1904
263 Fleming, Henry Stuart, 1, Broadway, New York City, U.S.A. ... ... June 10, 1905
264 Fletcher, James, Granity, *via* Westport, New Zealand ... Oct. 14, 1905
265 Fletcher, Lancelot Holstock, Allerdale Coal Company, A.M. April 14, 1888
Limited, Colliery Office, Workington ... ... M. June 8, 1889
266*Fletcher, Walter, The Hollins, Bolton ... ... Dec. 14, 1895
267 Flint, John, Radcliffe House, Acklington, S.O., Northumberland... ... ... Jan. 19, 1895
268 Ford, Mark, Washington Colliery, Washington Station, S.O., County Durham ... ... Aug. 3, 1895

Date of Election and of Transfer.

269 Ford, Stanley Horace, P.O. Box 2056, Johannesburg, Transvaal ... ... June 10, 1893

270 Forrest, John Charles, Holly Bank Colliery, Essington, Wolverhampton ... ... April 12, 1884

271 Forster, Alfred Llewellyn, Newcastle and Gateshead Water Company, Engineer's Office, Pilgrim Street, Newcastle-upon-Tyne ... ... June 8, 1901

272 Forster, John Henry Bacon, Whitworth House, Spennymoor ... ... S. Nov. 24, 1894
A. Aug. 7, 1897
M. Feb. 10, 1900

273 Forster, Joseph William, New Kleinfontein Company, P.O., Benoni, Transvaal ... ... Feb. 13, 1904

274 Forster, Richard Percival, Mount Pleasant, Spennymoor Feb. 14, 1903

275 Forster, Thomas Emerson, 3, Eldon Square, Newcastle-upon-Tyne (Vice-President, *Member of Council*) ... S. Oct. 7, 1876
A.M. Aug. 1, 1885
M. June 8, 1889

276 Foulis, John Thomas, Durban House, Ramsey, S.O., Isle of Man ... ... Feb. 9, 1907

277 Fox, George Charles, P.O. Box 1961, Johannesburg, Transvaal ... ... Feb. 14, 1903

278 Frecheville, William, 35, Queen Victoria Street, London, E.C. ... ... Feb. 15, 1896

279 Fryar, John William, Eastwood Collieries, near Nottingham ... ... A. June 14, 1890
M. June 12, 1897

280 Fryar, Mark, Denby Colliery, Derby ... ... S. Oct. 7, 1876
A.M. Aug. 4, 1883
M. June 8, 1889

281 Fryar, Thomas Lewis, Toowoomba, Queensland, Australia Dec. 9, 1905

282 Fryer, George Kellett, Bleak House, Broughton Moor, Maryport ... ... Dec. 14, 1901

283 Futers, Thomas Campbell, 17, Balmoral Gardens, Monkseaton, Whitley Bay, S.O., Northumberland ... ... Aug. 6, 1904

284 Galloway, Thomas Lindsay, 175, West George Street, Glasgow ... ... Sept. 2, 1876

285 Galloway, William, Cardiff ... ... April 23, 1887

286 Gallwey, Arthur Payne, Rand Club, Johannesburg, Transvaal ... ... S. Oct. 2, 1880
M. Oct. 10, 1891

287 Gascon y Miramon, Antonio, Carranza, 8, Madrid, Spain ... ... Aug. 2, 1902

288 Gibson, James, c/o W. E. Robarts, Acutts Arcade, Durban, Natal, South Africa ... ... A.M. Dec. 9, 1899
M. Feb. 13, 1904

289 Gifford, Henry J., The Champion Reef Gold-mining Company, Champion Reef, Mysore State, India ... Oct 14, 1893

290 Gillman, Gustave, Aguilas, Provincia de Murcia, Spain Aug. 2, 1902

291 Gipps, F. G. de Visme, Stannary Hills Mines and Tramway Company, North Queensland, Australia... ... ... April 25, 1896

292 Goninon, Richard, Menzies Consolidated Gold-mines, Limited, Menzies, Western Australia ... ... June 10, 1906

293 Goodwin, Robert Harvey, Karabournou Mercury-mine, c/o C. Whittall and Company, Smyrna, Turkey ... Oct. 13, 1900

294 Goodwin, William Lawton, School of Mining, Kingston, Ontario, Canada ... ... Feb. 11, 1899

295 Gore, Henry, Victorian Gold Estates, Limited, National Mutual Buildings, 395, Collins Street, Melbourne, Victoria, Australia ... ... April 28, 1900

296 Gough, George Henry, Singareni Collieries, Yellandu (Deccan), India ... ... Aug. 4, 1900

297 Gouldie, Joseph, Prospect House, Winder, Frizington, S.O., Cumberland ... ... Aug. 5, 1893

298 Gowland, Joseph Edwin, Mina Caridad, Aznalcollar, Sevilla, Spain ... ... June 11, 1904

299 Graham, Edward, Jun., Bedlington Colliery, Bedlington, S.O., Northumberland ... ... Aug. 1, 1896

		Date of Election and of Transfer.
300	Grave, Percy, Concepcion del Oro, Estado de Zacatecas, Mexico	Oct. 13, 1900
301	Greaves, J. O., Westgate, Wakefield	Aug. 7, 1862
302	Green, Edwin Henry, P.O. Box 1978, Johannesburg, Transvaal	Aug. 1, 1903
303	Green, Joseph, Crag House, Ferry Hill	Dec. 13, 1902
304	Green, John Dampier. P.O. Box 340, Johannesburg, Transvaal	A.M. Dec. 14, 1901 M. Aug. 2, 1902
305	Greener, George Alfred, 6, Tyvica Crescent, Pontypridd	Feb. 10, 1900
306	Greener, Thomas Young, West Lodge, Crook, S.O., County Durham (Retiring Vice-President, *Member of Council*)	S. July 2, 1872 A.M. Aug. 2, 1879 M. June 8, 1889
307	Greenwell, Allan, 30 and 31, Furnival Street, Holborn, London, E.C.	Aug. 4, 1900
308	Greenwell, George Clementson, Poynton, Stockport	S. March 6, 1869 M. Aug. 3, 1872
309	Gresley, William Stukeley, Avenue Road, Duffield, Derby	A.M. Oct. 5, 1878 M. Aug. 3, 1889
310	Grey, Frederick William, Cannon Street House, 110, Cannon Street, London, E.C.	July 14, 1896
311	Gribben, Edward, Durham, Georgetown, Queensland, Australia	April 9, 1904
312	Griffith, Nathaniel Maurice, The Sondage Syndicate, Limited, Tilmanstone Sinking, Eythorne, Dover	S. Nov. 24, 1894 M. Feb. 11, 1899
313	Griffith, Thomas, Maes Gwyn, Cymmer, Porth, Pontypridd	April 9, 1904
314*	Grundy, James. Siterampore, E.I. Railway, Bengal, India	June 13, 1896
315	Gummerson, James M., 35, Birkbeck Road, Acton, London, W.	A.M. June 10, 1899 M. Dec. 12, 1903
316	Guthrie, James Kenneth, 3, Oak Road, Newton Park, Leeds	Aug. 3, 1889
317	Haddock, William Thomas, c/o Kleinfontein Group, Benoni, Transvaal	S. Oct. 7, 1876 A.M. Aug. 1, 1885 M. June 8, 1889
318	Halbaum, Henry Wallace Gregory, 3, Mitchell Street, Birtley, S.O., County Durham	April 8, 1899
319	Hall, Frederick, Fernleigh, Highfield, Workington	Oct. 14, 1893
320	Hall, John Charles, 72, Dundas Street, Sunderland	A. Dec. 14, 1889 M. Aug. 3, 1895
321	Hall, Joseph John, Ashington Colliery, Morpeth	Dec. 10, 1904
322	Hall, Matthias Stokoe. Springwell Villa, Bishop Auckland	Feb. 14, 1874
323	Hall, Robert William, Thrislington Colliery, West Cornforth, S.O., County Durham	A. Dec. 13, 1902 M. June 8, 1907
324	Hall, Tom, Ryhope Colliery, Sunderland	June 8, 1889
325	Hallas, George Henry, Huyton, Liverpool	S. Oct. 7, 1876 A.M. Aug. 4, 1883 M. June 8, 1889
326	Hallimond, William Tasker. Crown Deep, Limited, P.O. Box 102, Fordsburg, Transvaal	Dec 14, 1889
327	Halse, Edward, 15, Clarendon Road, Notting Hill, London, W. All communications sent to Boxgrove, St. Margaret's Road, East Twickenham, Middlesex	A.M. June 13, 1885 M. Aug. 3, 1889
328	Hamilton, Edward. Rig Wood, Saltburn-by-the-Sea	S. Nov. 1, 1873 A.M. Aug. 2, 1879 M. June 8, 1889
329*	Hancock, Henry Lipson, Wallaroo and Moonta Mining and Smelting Company, Limited, Wallaroo, South Australia	Dec. 14, 1895
330	Hancock, Henry Richard, Nalyappa, Moonta, South Australia	A.M. Aug. 4, 1894 M. Nov. 24, 1894
331	Hann, Robert, Jun., Denehurst, Ferry Hill	Oct. 14, 1895
332	Hannah, David, Brynderwen, Ferndale, Pontypridd	Feb. 9, 1895
333	Hare, Samuel. Murton Colliery, *via* Sunderland (*Member of Council*)	S. Aug. 2, 1879 M. Aug. 1, 1891

		Date of Election and of Transfer.
334	HARLE, PETER, Page Bank Colliery, County Durham ...	Oct. 8, 1892
335	HARLE, RICHARD, Browney Colliery, Durham ...	April 7, 1877
336	HARLE, ROBERT ALFRED, Alma Cottage, Campbells Hill, West Maitland, New South Wales, Australia	A. April 14, 1894 M. Oct. 12, 1901
337	HARRIS, DAVID, Elands Laagte Collieries, Limited, Elands Laagte, Natal, South Africa	A.M. June 12, 1897 M. April 13, 1901
338	HARRIS, HOWARD, P.O. Box 752, Durban, Natal, South Africa	Aug. 7, 1897
339	HARRIS, WILLIAM SCORER, Kibblesworth, Gateshead-upon-Tyne	S. Feb. 14, 1874 A.M. Aug. 7, 1880 M. June 8, 1889
340	HARRISON, CHARLES AUGUSTUS, North Eastern Railway, Newcastle-upon-Tyne	June 21, 1894
341	HARRISON, GEORGE BRABBON, H.M. Inspector of Mines, Swinton, Manchester	Aug. 6, 1892
342	HARRISON, WILLIAM B., Brownhills Collieries, near Walsall	April 6, 1867
343	HASELDEN, ARTHUR, Linares, Provincia de Jaen, Spain ...	A.M. Dec. 11, 1897 M. April 2, 1898
344*	HAWKER, EDWARD WILLIAM, Adelaide Club, Adelaide, South Australia	Oct. 12, 1895
345	HAWKINS, THOMAS SPEAR, Millpond House, Hayle, S.O., Cornwall	Aug. 6, 1904
346	HAY, JAMES, Jun., Widdrington Colliery, Acklington, S.O., Northumberland	S. Sept. 4, 1869 M. Aug. 4, 1874
347	HEADS, ROBERT WILLIAM, Bangkok, Siam	June 14, 1902
348	HEDLEY, ARTHUR MORTON, Blaydon Burn, Blaydon-upon-Tyne, S.O., County Durham (*Member of Council*) ...	A. Nov. 24, 1894 M. Dec. 12, 1903
349	HEDLEY, SEPTIMUS H., Langholme, Roker, Sunderland ...	S. Feb. 15, 1879 A.M. Aug. 1, 1885 M. Aug. 3, 1889
350	HEDLEY, WILLIAM, Eighton Lodge, Low Fell, Gateshead-upon-Tyne	Feb. 13, 1897
351	HEINZE, F. AUGUSTUS, Butte, Montana, U.S.A.	Dec. 11, 1897
352	HEISE, FRITZ, Hernerstrasse, 45, Bochum, Germany ...	Aug. 5, 1905
353	HENDERSON, CHARLES, Cowpen Colliery Office, Blyth ...	Dec. 9, 1899
354	HENDY, JOHN CARY BAKER, Etherley, *via* Darlington ...	Oct. 14, 1893
355	HENRIKSEN, GUDBRAND, Inspector of Mines, Niels Juels Gade, 44, Christiania, Norway	Aug. 6, 1904
356	HERRMANN, HENRY J. A., Lokken Grube, Meldalen, Norway	Dec. 10, 1898
357	HESLOP, CHRISTOPHER, Woodside, Marske Mill Lane, Saltburn-by-the-Sea	S. Feb. 1, 1868 M. Aug. 2, 1873
358	HESLOP, GRAINGER, North Moor House, Sunderland ...	Oct. 5, 1872
359	HESLOP, MICHAEL, Rough Lea Colliery, Willington, S.O., County Durham	A. Feb. 10, 1894 M. June 21, 1894
360	HESLOP, SEPTIMUS, New Beerbhoom Coal Company, Limited, Asansol, Bengal, India	Oct. 12, 1895
361	HESLOP, THOMAS, Randolph Colliery, Evenwood, Bishop Auckland	S. Oct. 2, 1880 A.M. Aug. 4, 1888 M. Aug. 3, 1889
362	HESLOP, WILLIAM TAYLOR, St. George's Colliery, Hatting Spruit, Natal, South Africa	Aug. 3, 1895
363	HEWITSON, THOMAS, Associated Northern Company, Kalgoorlie, Western Australia	Dec. 9, 1899
364*	HEWITT, GEORGE COLTHURST, Serridge House, Coalpit Heath, Bristol	June 3, 1871
365	HEWLETT, ALFRED, Haseley Manor, Warwick	March 7, 1861
366	HEWLETT, ERNE, Ammanford Colliery Company, Limited, Ammanford, S.O., Carmarthenshire	Oct. 10, 1896
367	HEWLETT, HOWE, Clock Face Colliery, Sutton Oak, St. Helens	Feb. 13, 1904
368	HIGSON, JACOB, Crown Buildings, 18, Booth Street, Manchester	Aug. 7, 1862
369	HILL, ALBERT JAMES, New Westminster, British Columbia	A.M. Dec. 10, 1898 M. Dec. 8, 1900

		Date of Election and of Transfer.
370	Hill, William, Hill Crest, Dordon, Tamworth	A.M. June 9, 1883
		M. Aug. 3, 1889
371	Hilton, Thomas Worthington, Wigan Coal and Iron Company, Limited, Wigan	Aug. 3, 1865
372	Hindson, Thomas, Framwellgate Colliery, near Durham	Dec. 9, 1905
373	Hodgkin, Jonathan Edward, Shelleys, Darlington ...	Dec. 13, 1902
374	Hodgson, Jacob, Cornsay Colliery, Durham	June 8, 1895
375	Hogg, Charles Edward, 34 and 36, Gresham Street, London, E.C.	Oct. 12, 1895
376	Hogg, John, Thornley Colliery Office, Thornley, S.O., County Durham	Dec. 12, 1903
377	Holberton, Walter Twining, Copiapo Mining Company, Limited, Casilla 48, Copiapo, Chile, South America ...	June 9, 1900
378	Holliday, Martin Forster, Langley Grove, Durham ...	May 1, 1875
379	Holliday, Norman Stanley, Boyne Villa, Langley Moor, Durham	S. April 10, 1897
		M. Feb. 13, 1904
380	Homersham, Edwin Collett, 19, Broad Street Avenue, Blomfield Street, London, E.C.	Feb. 9, 1901
381	Homersham, Thomas Henry Collett, Vulcan Iron Works, Thornton Road, Bradford	Aug. 6, 1898
382	Hood, William Walker, Glyncornel, Llwynypia, Pontypridd	April 9, 1904
383	Hooper, Edward, Salisbury House, London Wall, London, E.C.	A.M. June 4, 1881
		M. April 14, 1894
384	Hooper, James, Derwent, St. Agnes, Scorrier, S.O., Cornwall	Feb. 13, 1904
385	Hope, Charles Edward, Vancouver, British Columbia ...	Aug. 1, 1903
386	Hope, Edmund Louis, Abbottabad, N.W. Frontier, India	Oct. 9, 1897
387	Hopkins, Edward	Oct. 8, 1889
388	Hopwood, William, Vron Haul, Buckley, Chester ...	Aug. 3, 1901
389	Horswill, Frederick J., 1218, Chesnut Street, Oakland, California, U.S.A.	Oct. 14, 1899
390	Hosking, James, P.O. Box 1617, Johannesburg, Transvaal	June 21, 1894
391*	Hoskold, Carlos A. Lynes, First Engineer, Inspector of the National Department of Mines and Geology, Calle Charcas, 1222, Buenos Aires, Argentine Republic, South America	June 8, 1895
392	House, John, Rosebridge and Douglas Bank Collieries Company, Limited, Wigan	June 13, 1896
393	Howells, David, P.O Box 5559, Johannesburg, Transvaal	Feb. 13, 1904
394	Howes, Frank T., Hyderabad (Deccan) Company, Limited, Secunderabad, India	A. Dec. 10, 1892
		M. Oct. 14, 1893
395	Howson, Charles, Harraton Colliery, Chester-le-Street	S. Dec. 14, 1901
		A. Aug. 4, 1906
		M. June 8, 1907
396	Humble, John, West Pelton House, Beamish, S.O., County Durham	Feb. 8, 1902
397	Humble, William, Lawson Street, Hamilton, Newcastle, New South Wales, Australia	Oct. 14, 1893
398	Humphris, Henry, Blaenau Festiniog	Oct. 13, 1900
399	Hunter, Christopher, Cowpen Colliery Office, Blyth ...	A. Dec. 10, 1892
		M. Dec. 12, 1903
400	Hunter, Robert, Gympie, Queensland, Australia	June 14, 1902
401	Hurst, George, 9, Framlington Place, Newcastle-upon-Tyne	S. April 14, 1883
		M. Aug. 1, 1891
402	Hutchinson, John William, Llwyncelyn House, Porth, near Pontypridd	Oct. 14, 1899
403	Hutton, John George, Torbane, Mudgee Line, New South Wales, Australia	Dec. 10, 1904
404	Jackson, Edmund, Tangier Buildings, Whitehaven ...	April 8, 1905
405	Jackson, Walter Geoffrey, Prestwick, Witley, Godalming	June 7, 1873
406	Jacob, Frederick Ernest, Westbrook, Swansea	Dec. 12, 1903

		Date of Election and of Transfer.
407	JACOBS, LIONEL ASHER, Giridih, E.I.R., Bengal, India ..	S. Aug. 4, 1900 A. Aug. 4, 1906 M. April 13, 1907
408	JAMES, JOHN	Feb. 13, 1904
409	JAMES, THOMAS, Ivy Cottage, Neath Abbey, Neath ...	April 12, 1902
410	JAMES, WILLIAM HENRY TREWARTHA, Finsbury House, Blomfield Street, London, E.C.	Dec. 12, 1896
411	JAMIESON, JOHN WILLIAM, Medomsley, S.O., County Durham	Aug. 2, 1902
412	JANITZKY, EDWARD, Pymble, near Sydney, New South Wales, Australia	Aug. 6, 1904
413	JEFFERSON, FREDERICK, Whitburn Colliery, South Shields	Dec. 11, 1897
414	JEFFREYS, JAMES HENRY, The Lisboa Mining and Development Company, Limited, 32, Great St. Helens, London, E.C.	Oct. 8, 1904
415	JENKINS, CHARLES WARREN BOWEN, Elonera, Chalsword, North Sydney, New South Wales, Australia	Oct. 9, 1897
416	JENKINS, PHILIP THOMAS, Gwylfa, Llansamlet. S.O. Glamorgan	Dec. 10, 1904
417	JENKINS, WILLIAM, Ocean Collieries, Treorchy, Pontypridd	Dec. 6, 1862
418	JENNINGS, THOMAS BRYANT, P.O. Box 1565, Johannesburg, Transvaal	Dec. 10, 1904
419	JEPSON, HENRY, 39, North Bailey, Durham	S. July 2, 1872 A.M. Aug. 2, 1879 M. June 8, 1889
420	JOBLING, JOHN WILLIAM, Clifton Cottage, Burnley ...	June 13, 1896
421*	JOBLING, THOMAS EDGAR, Bebside, S.O., Northumberland (*Member of Council*)	S. Oct. 7, 1876 A.M. Aug. 4, 1883 M. June 8, 1889
422	JOHNS, BENNET, Station Road, Keswick	Dec. 9, 1905
423*	JOHNS, JOHN HARRY (HENRY), P.O. Box 231, Johannesburg, Transvaal	June 21, 1894
424	JOHNSON, EDWARD	Dec. 9, 1905
425	JOHNSON, HENRY HOWARD, The Village Deep, Limited, P.O. Box 1145, Johannesburg, Transvaal	Feb. 13, 1904
426	JOHNSON, JAMES, Boldon Lodge, East Boldon, S.O., County Durham	A. Aug. 6, 1898 M. Dec. 12, 1903
427	JOHNSTON, J. HOWARD, c/o Backus and Johnston, Lima, Peru, South America	Feb. 10, 1894
428	JOICEY, WILLIAM JAMES, Sunningdale Park, Berkshire ...	March 6, 1869
429	JONES, CLEMENT, Neath Colliery, Cessnock, New South Wales, Australia	Dec. 8, 1906
430	JONES, EVAN, Plas Cwmorthin, Blaenau Festiniog	April 13, 1907
431	JONES, JACOB CARLOS, Wollongong, New South Wales, Australia	Aug. 6, 1892
432	JONES, PERCY HOWARD, Ty Ceirios, Pontnewynydd, Pontypool	Oct. 11, 1902
433	JONES, THOMAS, 1, Princes Street, Great George Street, Westminster, London, S.W.	June 12, 1897
434	JORDAN, JOHN EVAN, P.O. Box 5355, Johannesburg, Transvaal	Feb. 13, 1904
435	JOYNES, JOHN JAMES, Ferndale, Lydbrook, Gloucestershire	Aug. 6, 1904
436	JUDD, HENRY ALEXANDER, The Merton's Reward Gold-mining Company, Limited, Mertondale, Western Australia	Oct. 8, 1898
437	KAYLL, ALFRED CHARLES, Gosforth, Newcastle-upon-Tyne	S. Oct. 7, 1876 M. Aug. 3, 1889
438	KAYSER, HENRICH WILHELM FERDINAND, Launceston, Tasmania	Nov. 24, 1894
439	KEARNEY, JOSEPH MUSGRAVE, Wankie (Rhodesia) Coal, Railway and Exploration Company, Limited, Wankie, Rhodesia, South Africa	Aug. 1, 1903
440	KEIGHLEY, FREDERICK CHARLES, Uniontown, Fayette County, Pennsylvania, U.S.A.	Aug. 4, 1900

		Date of Election and of Transfer.
441	Kellett, Matthew Henry, St. Helen's Colliery, Bishop Auckland	S. April 11, 1891 M. Aug. 3, 1895
442	Kerr, David Gillespie, Rowandell, Chryston, Glasgow	Aug. 4, 1900
443	Kidd, Thomas, Jun., Linares, Provincia de Jaen, Spain	Aug. 3, 1895
444	Kirkby, William, c o Aire and Calder Navigation, Leeds	A.M. April 2, 1898 M. Aug. 6, 1904
445	Kirkup, Austin, Manor House, Penshaw, Fence Houses	S. April 9, 1892 M. June 12, 1897
446	Kirkup, Frederic Octavius, Garesfield Colliery, Rowlands Gill, Newcastle-upon-Tyne	S. April 9, 1892 A.M. April 25, 1896 M. Feb. 14, 1903
447	Kirkup, John Philip, Burnhope, Durham (*Member of Council*)	April 11, 1891
448	Kirkup, Philip, Leafield House, Birtley, S.O., County Durham (*Member of Council*)	S. March 2, 1878 A.M. Aug. 7, 1886 M. Aug. 3, 1889
449	Kirsopp, John, Jun., Lamesley, Gateshead-upon-Tyne	June 9, 1900
450	Kirton, Hugh, Kimblesworth Colliery, Chester-le-Street	S. April 7, 1877 A.M. Aug. 1, 1885 M. June 8, 1889
451	Kitchin, James Bateman, Woodend House, Bigrigg, S.O., Cumberland	Aug. 5, 1905
452	Klepetko, Frank, 307, Battery Park Building, 21-24, State Street, New York City, U.S.A.	Oct. 13, 1900
453*	Knowles, Robert, Ednaston Lodge, near Derby	April 10, 1886
454	Knox, William, Horden Colliery, Castle Eden, S.O., County Durham	Oct. 13, 1906
455	Kondo, R., c o Furukawa Mining Office, 1, Icchome Taesucho, Kojimachi, Tokyo, Japan	June 21, 1894
456*	Kwang, Kwong Yung, Lincheng Mines, Lincheng, Chemin de Fer Pekin-Hankow, *via* Peking, North China	June 8, 1895
457	Lamb, Robert Ormston, Hayton, How Mill, Carlisle	Aug. 2, 1866
458	Lancaster, John, Overslade, near Rugby	March 2, 1865
459	Lancaster, John, Auchenheath, S.O., Lanarkshire	Sept. 7, 1878
460*	Landero, Carlos F. de, Apartado 3, Pachuca, Mexico	Feb. 15, 1896
461*	Laporte, Henry, 35, rue de Turin, Brussels, Belgium	May 5, 1877
462	Lathbury, Graham Campbell, Ingledene, Buxton	Feb. 14, 1903
463	Latimer, Hugh, South Durham Colliery, Eldon, Bishop Auckland	S. Feb. 15, 1896 A. Aug. 1, 1903 M. Feb. 11, 1905
464	Laverick, John Wales, 54, Manor House Road, Jesmond, Newcastle-upon-Tyne	A.M. Dec. 9, 1882 M. Aug 3, 1889
465	Lawn, James Gunson, King Edward Mine, Camborne	July 14, 1896
466	Lawrence, Henry, 13, Devonshire Place, Newcastle-upon-Tyne (*Member of Council*)	Aug. 1, 1868
467	Leach, Charles Catterall, Seghill Colliery, Seghill, Dudley, S.O., Northumberland (*Member of Council*)	S. March 7, 1874 A.M. Aug. 6, 1881 M. Aug. 4, 1883
468	Lebour, George Alexander Louis, Armstrong College, Newcastle-upon-Tyne	Feb. 1, 1873
469	Leck, William, H.M. Inspector of Mines, Cleator Moor, S.O., Cumberland	Nov. 24, 1894
470	Lee, John Wilson Richmond, 70, St. Helen's Gardens, North Kensington, London, W.	Aug. 5, 1893
471	Lee, Percy Ewbank, Pontop Colliery, Annfield Plain, S.O., County Durham	Feb. 11, 1905
472	Lee, Richard Henry Lovelock, Pekin Syndicate, Ja-mei-sen Works, *via* Wei Hui Fu, Honan, North China	Aug. 5, 1905
473	Leech, Arthur Henry, 11, King Street, Wigan	Feb. 9, 1901
474	Lewis, John Dyer, H.M. Inspector of Mines, Glanrhyd, Sketty Road, Swansea	Oct. 9, 1897
475	Lewis, Sir William Thomas, Bart., Mardy, Aberdare	Sept. 3, 1864
476	Liddell, Hugh	Feb. 11, 1905

		Date of Election and of Transfer.
477	LIDDELL, JOHN MATTHEWS, Togston Hall, Acklington, S.O., Northumberland	S. March 6, 1875 A.M. Aug. 6, 1881 M. June 8, 1889
478	LIDSTER, RALPH, Langley Park Colliery, Durham	April 4, 1903
479	LISBOA, MIGUEL ARROJADO RIBEIRO, Rua Costa Gama, Villa Japurá, Petropolis, Rio de Janeiro, Brazil, South America	Aug. 5, 1905
480	LISHMAN, ROBERT RICHARDSON, Bretby Colliery, Burton-upon-Trent	S. June 9, 1883 M. Aug. 1, 1891
481	LISHMAN, THOMAS, Hetton Colliery, Hetton-le-Hole, S.O., County Durham	S. Nov. 5, 1870 M. Aug. 3, 1872
482	LISHMAN, TOM ALFRED, Harton Colliery, Tyne Dock, South Shields	S. Nov. 24, 1894 A. Aug. 7, 1897 M. April 13, 1901
483	LISHMAN, WILLIAM ERNEST, 4, Field House Terrace, Durham	June 10, 1893
484	LISLE, JAMES, Kroonstad Coal Estate Company, Limited, P.O. Box 118, Klerksdorp, Transvaal	S. July 2, 1872 A.M. Aug. 3, 1878 M. June 8, 1889
485	LIVEING, EDWARD H., Brookfield House, Long Stanton, Cambridge	S. Sept. 1, 1877 A.M. Aug. 2, 1884 M. Aug. 3, 1889
486	LLEWELLIN, DAVID MORGAN, Glanwern Offices, Pontypool	May 14, 1881
487	LOCKWOOD, ALFRED ANDREW, 46, Marmora Road, Honor Oak, London, S.E.	June 12, 1897
488	LONG, ERNEST, c o W. T. Glover and Company, Limited, Trafford Park, Manchester	Aug. 4, 1906
489	LONSDALE, TALBOT RICHARD, Malton Colliery, near Durham	June 14, 1902
490*	LOUIS, DAVID ALEXANDER, 77, Shirland Gardens, London, W.	April 8, 1893
491	LOUIS, HENRY, 4, Osborne Terrace, Newcastle-upon-Tyne ...	Feb. 15, 1896
492	LOWDON, THOMAS, Hamsteels, near Durham	Dec. 14, 1889
493	LUPTON, ARNOLD, 7, Victoria Street, Westminster, London, S.W.	Nov. 6, 1869
494	LYALL, EDWARD, 4, Vane Terrace, Darlington	Oct. 14, 1905
495	MACARTHUR, JAMES DUNCAN, Bangkok, Siam	Oct. 13, 1906
496	MACARTHUR, JOHN STEWART, 74, York Street, Glasgow ...	April 8, 1893
497	MCCARTHY, EDWARD THOMAS, 29, Royal Crescent, Holland Park Avenue, London, W.	A.M. Oct. 8, 1887 M. Aug. 3, 1889
498	MCCREATH, JAMES, 208, St. Vincent Street, Glasgow ...	March 5, 1870
499	MCDONALD, JOHN ALEXANDER, c o James E. McDonald, 4, Chapel Street, Cripplegate, London, E.C.	June 9, 1900
500	MCDOWELL, BENJAMIN FRANCIS, Manica Copper Development Company, Limited, Umtali, Rhodesia, South Africa ...	Dec. 12, 1903
501	MCFARLANE, JAMES ALEXANDER, Pilot Bay, British Columbia	April 12, 1902
502	MACFARLANE, RIENZI WALTON, Cherokee (Mexican) Proprietary, Limited, San Julian, *via* Parral, Chihuahua, Mexico	April 9, 1904
503	MCGEACHIE, DUNCAN, West Wallsend, New South Wales, Australia	Nov. 24, 1894
504	MCINERNY, AUGUSTIN JOSEPH, 16, rue d'Autriche, Tunis ...	Aug. 4, 1906
505	MCINTOSH, ROBERT, Assistant Inspector of Mines, Dunedin, New Zealand	April 9, 1904
506	MACKINTOSH, JAMES, Burrea Coal Company, Salanpur Colliery, Sitarampur, E.I.R., Bengal, India	Oct. 12, 1895
507	MCLELLAN, NEIL, Idsley House, Spennymoor	Dec. 13, 1902
508	MCMURTRIE, GEORGE EDWIN JAMES, Radstock, Bath ...	S. Aug. 2, 1884 M. Dec. 12, 1891
509	MCMURTRIE, JAMES, 5, Belvedere Road, Durdham Park, Bristol	Nov. 7, 1863
510	MCNEILL, BEDFORD, 25A, Old Broad Street, London, E.C.	Dec. 11, 1897
511	MADDISON, THOMAS ROBERT, Durkar House, near Wakefield	S. March 3, 1877 A.M. Aug. 6, 1881 M. June 8, 1889
512	MADDISON, W. H. F., The Lindens, Darlington	June 14, 1890
513	MALLMANN, PAUL J., 65 and 66, Wool Exchange, Coleman Street, London, E.C.	Oct. 8, 1904

		Date of Election and of Transfer.
514	Mammatt, John Ernest, 1, Albion Place, Leeds	Aug. 3, 1865
515	Manning, Arthur Hope, P.O. Box 88, Heidelberg, Transvaal	Dec. 11, 1897
516	Markham, C. E., Gloucester Villa, Darlington	S. Dec. 4, 1875
		A.M. Aug. 7, 1880
		M. June 8, 1889
517	Marks, Herbert T., c/o Royal Colonial Institute, Northumberland Avenue, London, W.C.	Oct. 12, 1901
518	Marr, James Heppell, Castlecomer, S.O., County Kilkenny	A. Feb. 13, 1897
		M. Dec. 12, 1903
519	Marriott, Hugh Frederick, c/o Wernher, Beit and Company, 1, London Wall Buildings, London, E.C. ...	Dec. 12, 1896
520	Martin, Henry William, Sherwood, Newport Road, Cardiff	Oct. 9, 1897
521	Martin, Tom Pattinson, 22, Station Road, Workington ...	April 4, 1903
522	Mathieson, Alexander, Hetton Colliery, Carrington, near Newcastle, New South Wales, Australia	Nov. 5, 1892
523	Matthews, Frederick Berkley, Lartington Hall, Darlington...	A.M. Dec. 9, 1882
		M. June 8, 1889
524	Matthews, John, c/o R. and W. Hawthorn, Newcastle-upon-Tyne	A.M. April 11, 1885
		M. Aug. 3, 1889
525	Mawson, Robert Bryham, Bickershaw House, Bickershaw, Wigan	June 11, 1892
526	May, George, The Harton Collieries, South Shields (Past-President, *Member of Council*)	March 6, 1862
527	Mein, Henry Johnson, Carterthorne Colliery, Toft Hill, Bishop Auckland	Dec. 9, 1899
528	Mellon, Henry, Brook Lea, Askam, S.O., Lancashire ...	April 25, 1896
529	Menzies, Joseph Frederick, Roslyn, Washington, U.S.A.	June 10, 1905
530	Merivale, John Herman, Togston Hall, Acklington, S.O., Northumberland (President, *Member of Council*)	May 5, 1877
531	Merz, Charles Hesterman, Collingwood Buildings, Collingwood Street, Newcastle-upon-Tyne	June 10, 1903
532	Metcalf, Alfred T., United Reefs (Sheba), Limited, Eureka City, De Kaap, South Africa	June 21, 1894
533	Middleton, Robert, Sheep Scar Foundry, Leeds	Aug. 1, 1891
534	Miles, Hon. Edward David, "Kinellan," New Farm, Brisbane, Queensland, Australia	April 9, 1904
535	Miller, James, c/o George Miller, 367, Byars Road, Hillhead, Glasgow	Aug. 4, 1894
536	Miller, John Henry, South Hetton, S.O., County Durham	A. Dec. 8, 1894
		M. April 4, 1903
537	Miller, J. P. K., H. C. Frick Coke Company, Scottdale, Pennsylvania, U.S.A.	Dec. 14, 1895
538	Mitchinson, Robert, Catchgate House, Annfield Plain, S.O., County Durham	Feb. 4, 1865
539	Molengraaff, Gustaaf Adolf Frederik, 43, van Stolberglaan, The Hague	Oct. 14, 1899
540	Montgomery, Alexander, State Mining Engineer, Department of Mines, Perth, Western Australia	Dec. 9, 1899
541	Moore, Marshall Greene, 840, Napoleon Street, Johnstown, Pennsylvania, U.S.A.	Feb. 11, 1905
542	Moore, Robert Thomas, 142, St. Vincent Street, Glasgow...	Oct. 8, 1892
543	Moore, Richard Walker, Somerset House, Whitehaven	S. Nov. 5, 1870
		M. Aug. 4, 1877
544	Moore, William, Loftus Mines, Loftus, S.O., Yorkshire ...	A.M. Nov. 19, 1881
		M. Aug. 3, 1889
545	Moreing, Charles Algernon, 20, Copthall Avenue, London, E.C.	Nov. 7, 1874
546	Morgan, John, Stanley Villa, Crook, S.O., County Durham	Dec. 9, 1905
547	Morison, John, Cramlington House, Northumberland ...	A.M. Dec. 4, 1880
		M. Aug. 3, 1889
548	Morland-Johnson, Edward Thomas, c/o H. T. Johnson, Railway Road, Urmston, Manchester	April 10, 1897
549	Morris, John, Lydbrook Colliery, Lydbrook, Gloucestershire	A. April 4, 1903
		M. Aug. 6, 1904

		Date of Election and of Transfer.
550	Morris, William, Waldridge Colliery, Chester-le-Street ...	Oct. 8, 1892
551	Morse, Willard S., c/o American Smelting and Refining Company, 71, Broadway, New York City, U.S.A. ...	June 13, 1896
552*	Mort, Arthur, c/o William Mort, 509, Edge Lane, Droylsden, Manchester	Dec. 9, 1899
553	Mount-Haes, Andrew, 3, Bellasis Avenue, Streatham Hill, London, S.W.	Dec. 10, 1904
554	Mountain, William Charles, The Hermitage, Gateshead-upon-Tyne	April 9, 1892
555	Mundle, Arthur, Murton Chambers, 8, Grainger Street, Newcastle-upon-Tyne	S. June 5, 1875 M. Aug. 4, 1877
556	Mundle, Harry Arthur, Marley Hill House, Swalwell, S.O., County Durham	June 14, 1902
557	Murray, William Cuthbert, Clifton House, Sherburn Colliery Station, near Durham	June 10, 1903
558	Ness, William Waters van, 622-623, Salisbury House, London Wall, London, E.C.	A.M. Aug. 7, 1897 M. Dec. 11, 1897
559	Nevin, John, Littlemoor House, Mirfield, S.O., Yorkshire	S. May 2, 1868 M. Aug. 5, 1871
560	Newbery, Frederick, 230, Camden Road, London, N.W.	A.M. April 2, 1898 M. Feb. 13, 1904
561	Newbigin, Henry Thornton, 3, St. Nicholas' Buildings, Newcastle-upon-Tyne	Oct. 13, 1894
562	Nicholson, Arthur Darling, H.M. Inspector of Mines, 2, Graingerville, Newcastle-upon-Tyne (*Member of Council*)	S. June 13, 1885 A. Aug. 4, 1894 M. Feb. 12, 1898
563	Nicholson, John Hodgson, Cowpen Colliery Office, Blyth (*Member of Council*)	S. Oct. 1, 1881 A. Aug. 3, 1889 M. April 8, 1893
564	Nicholson, Marshall, Middleton Colliery, Leeds	Nov. 7, 1863
565	Nierses, J. W., Kendwadih Colliery, Kusunda P.O., District Manbhoom, Bengal, India	Dec. 10, 1904
566	Nisbet, Norman, Houghton Colliery Office, Houghton-le-Spring, S.O., County Durham	S. Nov. 24, 1894 A. Aug. 3, 1901 M. Aug. 6, 1904
567	Noble, Thomas George, Sacriston Colliery, Durham ...	A. Feb. 13, 1892 M. June 8, 1895
568	Nómi, Aitaró, Hójó Colliery, Province of Buzen, Japan	Aug. 5, 1899
569	Northey, Arthur Ernest, Frias, c/o Señor José M. Restrepo, Honda, Republic of Colombia, South America	June 10, 1903
570	Oakes, Francis James, Jun., 58, Pearl Street, Boston, Massachusetts, U.S.A.	Feb. 10, 1900
571	Oates, Robert Joseph William, Rewah State Collieries, Umaria, C. India, Bengal Nagpur Railway	S. Feb. 10, 1883 A.M. Aug. 1, 1891 M. Dec. 12, 1891
572	O'Donahue, Thomas Aloysius, 72, Swinley Road, Wigan	A.M. Dec. 14, 1895 M. Oct. 9, 1897
573	Oldham, George, 25, Western Hill, Durham	Nov. 5, 1892
574	Olsen, Arnold Carl Louis, P.O. Box 1056, Johannesburg, Transvaal	Dec. 9, 1905
575	Ornsby, Edward Thomas, Benwell Colliery, Newcastle-upon-Tyne	Dec. 8, 1900
576	Ornsby, Robert Embleton, Seaton Delaval Colliery, Northumberland	June 11, 1898
577	Osborne, Francis Douglas, Gopeng, Perak, Federated Malay States	Feb. 14, 1903
578*	Oshima, Rokuro, No. 221, Yoyogi, Toyotama-gun, Tokyo, Japan	April 10, 1897
579	Owens, William David, Lehigh Valley Coal Company, 239, Philadelphia Avenue, Pittston, Pennsylvania U.S.A.	Feb. 11, 1905

		Date of Election and of Transfer.
580	Page, Davidge, 17, Surrey Street, Strand, London, W.C.	A.M. Oct. 10, 1903 M. Oct. 14, 1905
581	Paley, George, De Beers Mines, Kimberley, South Africa	Oct. 12, 1901
582	Palmer, Claude Bowes, Wardley Hall, Pelaw, Newcastle-upon-Tyne	A.M. Nov. 5, 1892 M. June 8, 1895
583	Palmer, Henry, Medomsley, S.O., County Durham (Vice-President, *Member of Council*)	S. Nov. 2, 1878 A.M. Aug. 4, 1883 M. Aug. 3, 1889
584	Pamely, Caleb, 22, Cromwell Road, Bristol	S. Sept. 5, 1868 M. Aug. 5, 1877
585	Pamplin, Eliah George, Cherry Hinton, Cambridge ...	Aug. 1, 1903
586	Parish, Charles Edward, 31, Hanger Lane, Ealing, London, W.	Feb. 10, 1900
587	Parker, Thomas, Wellington Pit, Whitehaven	June 10, 1899
588	Parrington, Matthew William, Wearmouth Colliery, Sunderland (Retiring Vice-President, *Member of Council*)	S. Dec. 1, 1864 M. Aug. 6, 1870
589	Parsons, Hon. Charles Algernon, Heaton Works, Newcastle-upon-Tyne (*Member of Council*)	A.M. June 12, 1886 M. Aug. 3, 1889
590	Pascoe, Thomas, Mount Boppy Gold-mining Company, Limited, Boppy Mountain, New South Wales, Australia	A.M. April 10, 1897 M. June 12, 1897
591	Paterson, Andrew James, 24, Lambton Quay, Wellington, New Zealand	June 11, 1898
592	Payne, Francis William, Government Insurance Building, Dunedin, New Zealand	Feb. 11, 1905
593	Peake, R. Cecil, Cumberland House, Redbourn, St. Albans	S. Feb. 7, 1880 A.M. Aug. 7, 1886 M. Aug. 3, 1889
594	Pearse, John Walter, 5, rue Robermont, Liége, Belgium	June 10, 1899
595	Pearson, Clement Alfred Ritson, South End Avenue, Darlington	June 11, 1904
596	Peel, Robert, New Brancepeth Colliery, Durham	Aug. 6, 1892
597	Peile, William, Southampton Lodge, Oakleigh Park, Whetstone, London, N.	S. Oct. 1, 1863 M. Aug. 6, 1870
598	Percy, Frank, Mining College, Wigan. *Transactions* sent to The Librarian, Wigan Free Library, Wigan... ...	Dec. 12, 1903
599	Phillips, Percy Clement Campbell, Wallsend Colliery, near Newcastle-upon-Tyne	June 10, 1903
600	Piercy, William, 32, Grainger Street West, Newcastle-upon-Tyne	June 11, 1904
601	Pingstone, George Arthur, P.O. Box 445, Bulawayo, Rhodesia, South Africa	A.M. June 11, 1898 M. Dec. 10, 1898
602	Plummer, John, Bishop Auckland	June 8, 1889
603	Pollitzer, Samuel Joseph, Terrys Chambers, 14, Castlereagh Street, Sydney, New South Wales, Australia ...	April 12, 1902
604	Poore, George Bentley, 1730, Cupouse Avenue, Scranton, Pennsylvania, U.S.A.	A.M. Dec. 10, 1898 M. April 8, 1899
605	Porter, John Bonsall, McGill University, Montreal, Quebec, Canada	Dec. 8, 1900
606	Powell, Charles Henry, Whipstick, South Coast, New South Wales, Australia	June 14, 1902
607	Powell, Henry Rees, P.O. Box 4931, Johannesburg, Transvaal	Dec. 10, 1904
608	Prest, John Joseph, Hardwick Hall, Castle Eden, S.O., County Durham	Feb. 9, 1901
609	Price, Francis Holborrow Glynn, Longlands Place, Swansea	June 10, 1899
610	Price, S. R., Dilston House, Corbridge, S.O., Northumberland	S. Nov. 3, 1877 A.M. Aug. 1, 1885 M. Aug. 3, 1889
611	Price, Samuel Warren, The Wern, Peterston-super-Ely, Cardiff...	Aug. 3, 1895
612	Pringle, John Archibald, Minas de Passagem, Ouro Preto, Brazil, South America	Dec. 10, 1898

		Date of Election and of Transfer.
613	Pringle, Robert William, Norfolk House, Laurence Pountney Hill, London, E.C.	Aug. 1, 1903
614*	Prior, Hon. Edward G., Victoria, British Columbia. *Transactions* sent to Thomas R. Stockett, Western Fuel Company, Nanaimo, British Columbia	Feb. 7, 1880
615	Pullon, Joseph Thomas, Rowangarth, North Park Road, Roundhay, Leeds	Feb. 11, 1905
616	Rae, John Livington Campbell, 40, Church Street, Newcastle, New South Wales, Australia	Oct. 14, 1899
617	Raine, Frederick James. Etherley Grange Colliery, Bishop Auckland	S. Feb. 15, 1896 A. Aug. 6, 1904 M. Feb. 9, 1907
618	Ramsay, John, Tursdale Colliery, Ferry Hill	A. April 27, 1895 M. Feb. 13, 1904
619	Randolph, Beverley S., Barkeley Springs, West Virginia, U.S.A.	Aug. 4, 1894
620	Rankin, Thomas Thomson, Mining and Technical College, Wigan	April 9, 1904
621	Rateau, Auguste, 7, rue Bayard, Paris, France .. .	Aug. 2, 1902
622	Ravenshaw, Henry Willock, Rutland House, Hanwell, London, W.	Feb. 15, 1896
623	Redman, Sydney George, 15, Osborne Terrace, Gosforth, Newcastle-upon-Tyne	Feb. 10, 1906
624	Redwood, Sir Boverton, Wadham Lodge, Wadham Gardens, London, N.W.	June 21, 1894
625	Rees, D. John Arthur, c o Frederick Napier White, H.M. Inspector of Mines, 12, St. James' Gardens, Swansea ...	Aug. 4, 1900
626*	Rees, Ithel Treharne, Guildhall Chambers, Cardiff ...	April 4, 1903
627	Rees, Robert Thomas, Glandare, Aberdare	Aug. 7, 1897
628	Rees, William Thomas, Maesyffynon, Aberdare ...	A.M. Oct. 9, 1897 M. Feb. 12, 1898
629	Reid, Arthur H., 20, South African Chambers, St. George's Street, Cape Town, South Africa	June 21, 1894
630	Reid, Francis, Riverside, Blackboys, S.O., Sussex... ...	April 9, 1892
631	Renwick, Thomas Charlton, Lumley Thicks, Fence Houses	April 14, 1894
632	Rhodes, Charles Edward, Lane End House, Rotherham	Aug. 4, 1883
633	Rhodes, Francis Bell Forsyth, United States Zinc Company, Pueblo, Colorado, U.S.A.	Feb. 10, 1894
634	Rich, Francis Arthur, Vincent Road, Remuera, Auckland, New Zealand	Aug. 5, 1899
635	Rich, William, Trevu, Camborne	A.M. June 9, 1888 M. Aug. 3, 1889
636	Richards, Thomas J., 53, Strand, Ferndale, Pontypridd	Oct. 10, 1896
637	Richardson, Henry, Eden Mount, Wetheral, Carlisle ...	March 2, 1865
638	Richardson, Nicholas, c o Mrs. James Richardson, South Ashfield, Newcastle-upon-Tyne	S. Dec. 12, 1896 A. Aug. 3, 1901 M. Dec. 14, 1901
639	Richardson, Robert, Summerhill House, Blaydon-upon-Tyne, S.O., County Durham	A. Feb. 8, 1890 M. Aug. 3, 1895
640	Ridley, Norman Backhouse, 2, Collingwood Street, Newcastle-upon-Tyne	June 8, 1895
641	Ritson, John Ridley, Burnhope Colliery, Lanchester, Durham	S. April 11, 1891 A.M. Aug. 3, 1895 M. Feb. 14, 1903
642	Ritson, Utrick Alexander, Millburn House, Newcastle-upon-Tyne	Oct. 7, 1871
643	Robbins, Percy Arthur, 60, Wall Street, New York City, U.S.A.	Oct. 12, 1901
644	Robert, Philip Rhinelander, 618, Orchard Lake Avenue, Pontiac, Michigan, U.S.A.	Feb. 10, 1900
645	Roberts, James, Jun., Perran House, Perranporth, S.O., Cornwall	Dec. 14, 1895

		Date of Election and of Transfer.
646	Roberts, John, Laxey, S.O., Isle of Man	Dec. 9, 1905
647	Roberts, Robert, Plas Meini, Festiniog, Blaenau Festiniog	Oct. 12, 1895
648	Roberts, Stephen, Luipaards Vlei Estate and Gold-mining Company, P.O. Box 53, Krugersdorp, Transvaal ...	April 28, 1900
649	Roberts, William, Bella Vista, Perranporth, S.O., Cornwall	Aug. 4, 1906
650	Robertson, Andrew, 49, Mining Exchange, Ballarat, Victoria, Australia	Aug. 7, 1897
651	Robertson, Daniel Alexander Wilberforce, Metropolitan Colliery, Helensburgh, near Sydney, New South Wales, Australia	Aug. 6, 1892
652*	Robertson, James Robert Millar, Linton, Pitt Street, Milsons Point, Sydney, New South Wales, Australia ...	Aug. 2, 1890
653*	Robins, Samuel Matthew, 28, Harefield Road, Brockley, London, S.E. *Transactions* sent to Thomas R. Stockett, Western Fuel Company, Nanaimo, British Columbia	Oct. 12, 1895
654	Robinson, Francis James, Wycliffe, South Parade, Whitley Bay, S.O., Northumberland	Oct. 13, 1906
655	Robinson, George, Boldon Colliery, S.O., County Durham	June 10, 1899
656	Robinson, G. C., Brereton and Hayes Colliery, Rugeley ...	Nov. 5, 1870
657	Robinson, George Henry, Jun., Peña Copper-mines, Limited, Minas Peña del Hierro, por Rio Tinto, Provincia de Huelva, Spain	S. Dec. 9, 1899 M. April 8, 1905
658	Robinson, John, High Hedgefield, Blaydon-upon-Tyne, S.O., County Durham	Feb. 10, 1900
659	Robinson, J. B., Colliery Offices, Tow Law, S.O., County Durham	Aug. 5, 1893
660	Robinson, John Thomas, South Medomsley Colliery, Dipton, S.O., County Durham	Feb. 13, 1892
661	Robinson, Robert Dobson, Tamworth Colliery Company, Tamworth	Feb. 9, 1901
662	Robinson, Timothy, Ryhope Colliery, Sunderland	Feb. 8, 1902
663	Robson, J. S., Butterknowle Colliery, Butterknowle, S.O., County Durham	May 15, 1862
664	Rodewald, Rudolf, Nenthead Mines, Nenthead, Alston, S.O., Cumberland	April 7, 1906
665	Ronaldson, James Henry, P.O. Box 1763, Johannesburg, Transvaal	Aug. 6, 1892
666	Ross, Hugh, Dean and Chapter Colliery, Ferry Hill ...	Aug. 6, 1892
667	Ross, John Alexander George, 11, Kingsley Place, Heaton, Newcastle-upon-Tyne	July 2, 1872
668	Routledge, William Henry, Woodfield Park, Blackwood, Newport, Monmouthshire	S. Oct. 7, 1876 A.M. Aug. 1, 1885 M. June 8, 1889
669	Rowlands, William Edward, 16, Penmaesglas Road, Aberystwyth	June 9, 1900
670	Rowley, Walter, 29, Park Row, Leeds	Aug. 5, 1893
671	Rumbold, William Richard, c/o A. T. L. Rumbold, 47, Watling Street, London, E.C.	June 14, 1902
672	Russell, Robert, Coltness Iron Works, Newmains, S.O., Lanarkshire	Aug. 3, 1878
673	Rutherford, Robert, Mainsforth, Ferry Hill	Oct. 11, 1902
674	Rutherford, William, Lindum House, Gateshead-upon-Tyne	Oct. 3, 1874
675	Rutherford, William, Jun., South Derwent Colliery, Annfield Plain, S.O., County Durham	Feb. 9, 1901
676*	Saise, Walter, Stapleton, Pristol	A.M. Nov. 3, 1877 M. Aug. 3, 1889
677	Sam, Thomas Birch Freeman, c/o F. and A. Swanzy, Cape Coast Castle, West Africa	Aug. 5, 1893
678	Samborne, John Stukely Palmer, Timsbury House, Bath	Aug. 1, 1891

		Date of Election and of Transfer.
679	Sample, James Bertram, Harraton Colliery, Chester-le-Street	S. Jan. 19, 1895 A. Aug. 4, 1900 M. Oct. 10, 1903
680*	Samwell, Nicholas, c/o The Mining and Metallurgical Bureau, Limited, Rangoon, Burma	April 13, 1901
681	Saunders, David William Alban, Worcester Chambers, Swansea	A.M. Feb 12, 1898 M. June 11, 1898
682	Saunders, William Thomas, Société des Mines de Tueo-Cheira, Puerto de Supe, Peru, South America	June 12, 1897
683*	Sawyer, Arthur Robert, P.O. Box 2202, Johannesburg, Transvaal	S. Dec. 6, 1873 A.M. Aug. 2, 1879 M. June 8, 1889
684	Schnabel, Leberecht Ferdinand Richard, Salisbury Buildings, 443, Bourke Street, Melbourne, Victoria, Australia	April 13, 1907
685	Scholer, Peter, 117, Frances Street, Bellevue, Johannesburg, Transvaal	A.M. Dec. 13, 1902 M. Feb. 10, 1906
686	Schwarz, Paul, Otto House, Fleet Street, Bishop Auckland	April 9, 1904
687	Scorer, John, c/o J. Young, 8, The Woodlands, Hexham...	Dec. 12, 1903
688	Scott, Anthony, Netherton Colliery, Nedderton, Newcastle-upon-Tyne	April 8, 1905
689	Scott, Charles F., Newbell, Consett, S.O., County Durham	S. April 11, 1874 M. Aug. 4, 1877
690	Scott, Elgin, Boryslaw, Galicia, Austria	Aug. 4, 1894
691	Scott, Ernest, Close Works, Newcastle-upon-Tyne ...	April 9, 1892
692	Scott, Edward Charlton, Woodside Cottage, Totley Rise, Sheffield	A. Oct. 8, 1892 M. Feb. 11, 1899
693	Scott, Frederick Bowes, 28, Queen Street, London, E.C.	Dec. 14, 1895
694	Scott, George Henry Hall, c/o Thomas Emerson Forster, 3, Eldon Square, Newcastle-upon-Tyne	S. April 12, 1902 M. Dec. 8, 1906
695	Scott, Herbert Kilburn, 46, Queen Victoria Street, London, E.C.	Oct. 11, 1902
696	Scoular, George, St. Bees, S.O., Cumberland	July 2, 1872
697	Selby, John Baseley, Leigh	April 25, 1896
698	Senstius, Friedrich, Wester holter Weg, 43, Recklinghausen, Westphalia, Germany	June 9, 1906
699	Severs, Joseph, North Walbottle, Newburn, S.O., Northumberland	June 8, 1901
700	Severs, William, Beamish, S.O., County Durham... ...	A. Nov. 5, 1892 M. Dec. 8, 1900
701	Shanks, John, 10, Church Road, Harrington, S.O., Cumberland	Aug. 5, 1905
702	Sharp, Jacob, Lambton House, Fence Houses	Dec. 14, 1901
703*	Shaw, James, The Terraces, North Adelaide, South Australia	Dec. 12, 1896
704	Shaw-Duncan, William, Rio Rimal Copper Company, Limited, 17, Fenchurch Street, London, E.C. ..	Oct. 14, 1905
705	Sheafer, Arthur Whitcomb, Pottsville, Pennsylvania, U.S.A.	Aug. 4, 1894
706	Shewan, Thomas, Saint Hilda Colliery, South Shields ...	Aug. 1, 1903
707	Shiel, John, 6, Windsor Terrace, Newcastle-upon-Tyne ...	May 6, 1871
708	Shipley, Thomas B., 252, Market Street, Jeppe, Transvaal. *Transactions* sent to c/o Andrew Reid & Company, Limited, Newcastle-upon-Tyne	A.M. Aug. 2, 1884 M. Aug. 3, 1889
709	Shute, Charles Ashley, 30, Woodlands Terrace, Darlington	April 11, 1874
710	Simon, Frank, P.O. Box 2986, Johannesburg, Transvaal ...	Dec. 14, 1895
711	Simpson, Charles Liddell, Engine Works, Grosvenor Road, Pimlico, London	April 8, 1893
712	Simpson, F. L. G., Mohpani Coal-mines, Gadawarra, C.P., India	A.M. Dec. 13, 1884 M. Aug. 3, 1889
713	Simpson, Frank Robert, Hedgefield House, Blaydon-upon-Tyne, S.O., County Durham (*Member of Council*) ...	S. Aug. 4, 1883 M. Aug. 1, 1891
714	Simpson, John, Heworth Colliery, Felling, S.O., County Durham (Vice-President, *Member of Council*)	S. Dec. 6, 1866 M. Aug. 1, 1868

		Date of Election and of Transfer.
715	SIMPSON, JOHN BELL, Bradley Hall, Wylam, S.O., Northumberland (PAST-PRESIDENT, *Member of Council*) ...	Oct. 4, 1860
716	SIMPSON, ROBERT ROWELL, Department of Mines, 6, Dacres Lane, Calcutta, India	S. Aug. 3, 1895 A. Aug. 2, 1902 M. Oct. 11, 1902
717	SIMPSON, THOMAS VENTRESS, Throckley Colliery, Newburn, S.O., Northumberland	S. Dec. 14, 1895 A. Aug. 2, 1902 M. Dec. 13, 1902
718	SKERTCHLEY, SYDNEY A. R., Tuxpam, Vera Cruz, Mexico	April 13, 1901
719	SLADDEN, HARRY, P.O. Box 2844, 6, Barnato Buildings, Johannesburg, Transvaal	Nov. 24, 1894
720	SLINN, THOMAS, 40, Park Avenue, Whitley Bay, S.O., Northumberland	July 2, 1872
721	SMART, ALEXANDER, c/o Frazer and Chalmers, Limited, Erith, S.O., Kent	Feb. 10, 1894
722*	SMITH, RICHARD CLIFFORD, Ashford Hall, Bakewell ...	Dec. 5, 1874
723	SMITH, ROBERT FLEMING, Hunters Villa, Parkside, Cleator Moor, S.O., Cumberland	Aug. 6, 1904
724	SMITH, WILLIAM, P.O. Box 653, Johannesburg, Transvaal ...	Oct. 11, 1902
725	SMITH, WILLIAM WOODEND, Crossgill House Frizington, S.O., Cumberland	Aug. 6, 1904
726	SOPWITH, ARTHUR, Cannock Chase Collieries, Walsall ...	Aug. 6, 1863
727	SOUTHERN, EDMUND OCTAVIUS, North Seaton Hall, Morpeth	S. Dec. 5, 1874 A.M. Aug. 1, 1885 M. June 8, 1889
728	SOUTHERN, JOHN, Heworth Colliery, Felling, S.O., County Durham	A. Dec. 14, 1889 M. April 8, 1899
729	SOUTHERN, R. W. A., 33, The Parade, Cardiff	Aug. 3, 1865
730	SOUTHWOOD, REGINALD THOMAS ENFIELD, Nether House, Spencer Road, Putney, London, S.W.	Feb. 10, 1906
731	SPENCE, ROBERT FOSTER, Backworth, Newcastle-upon-Tyne	S. Nov. 2, 1878 A.M. Aug. 2, 1884 M. Aug. 4, 1889
732	SPENCER, FRANCIS H., Pickwra, Bolney, Haywards Heath	Dec. 13, 1890
733	SPENCER, JOHN WATSON, Newburn, S.O., Northumberland	May 4, 1878
734	SQUIRE, JOHN BARRET, 7, Clifton Hill, St. John's Wood, London, N.W.	June 8, 1895
735	STANLEY, GEORGE HARDY, Technical Institute, Johannesburg, Transvaal	April 12, 1902
736	STEAVENSON, ADDISON LANGHORNE, Durham (PAST-PRESIDENT, *Member of Council*)	Dec. 6, 1855
737	STEAVENSON, CHARLES HERBERT, Redheugh Colliery, Gateshead-upon-Tyne (*Member of Council*)	S. April 14, 1883 A. Aug. 1, 1891 M. Aug. 3, 1895
738	STEEL, ROBERT, Woodhouse, Whitehaven	Aug. 5, 1905
739	STEPHENSON, RALPH, West Stanley Colliery, Stanley, S.O., County Durham	Dec. 10, 1904
740	STEVENS, ARTHUR JAMES, Uskside Iron Works, Newport, Monmouthshire	April 8, 1893
741	STEVENS, JAMES, 9, Fenchurch Avenue, London, E.C. ...	Feb. 14, 1885
742	STEVINSON, PETER B., Dunholm, Lesbury Road, Heaton, Newcastle-upon-Tyne	April 9, 1904
743	STEWART, WILLIAM, Foxwood, Kent Road, Harrogate ...	S. Oct. 8, 1898 M. April 9, 1904
744	STEWART, WILLIAM, Tillery Collieries, Abertillery, S.O., Monmouthshire	June 8, 1895
745	STOBART, FRANK, Biddick Hall, Fence Houses	S. Aug. 2, 1873 A.M. Aug. 5, 1882 M. June 8, 1889
746	STOBART, HENRY TEMPLE, Wearmouth Colliery, Sunderland	S. Oct. 2, 1880 A.M. Aug. 4, 1888 M. Aug. 3, 1889
747	STOBART, WILLIAM RYDER, Etherley Collieries, County Durham	Oct. 11, 1890

		Date of Election and of Transfer.
748	STOKER, ARTHUR P., Ouston House, near Chester-le-Street	S. Oct. 6, 1877
		A.M. Aug. 1, 1885
		M. Aug. 3, 1889
749	STOKOE, JAMES, Herrington Lodge, West Herrington, *via* Sunderland	A. Nov. 24, 1894
		M. Dec. 10, 1904
750	STONE, ARTHUR, Heath Villas, Hindley, Wigan	June 13, 1896
751*	STONIER, GEORGE ALFRED, 8, Bedford Road, Bedford Park, London, W.	June 11, 1904
752	STOREY, WILLIAM, Urpeth Villas, Beamish, S.O., County Durham	April 12, 1902
753	STRAKER, J. H., Howden Dene, Corbridge, S.O., Northumberland	Oct. 3, 1874
754	STREATFIELD, HUGH SIDNEY, Ryhope, Sunderland	A.M. June 8, 1889
		M. Aug. 3, 1889
755	STUART, DONALD MCDONALD DOUGLAS, Redland, Bristol	June 8, 1895
756	SULMAN, HENRY LIVINGSTONE, 44, London Wall, London, E.C.	Feb. 11, 1899
757	SUTCLIFFE, RICHARD, Horbury, Wakefield	June 14, 1902
758	SUTHERLAND, EDGAR GREENHOW, West Rainton, Fence Houses	Dec. 10, 1904
759	SUTTON, WILLIAM, Grosmont, 46, Palace Road, Streatham Hill, London, S.W.	April 28, 1900
760	SWALLOW, JOHN, East Pontop Colliery, Annfield Plain, S.O., County Durham	May 2, 1874
761	SWALLOW, RALPH STOREY, Langley Park, Durham	A. Dec. 9, 1899
		M. Dec. 12, 1903
762	SWALLOW, WARDLE ASQUITH, Tanfield Lea, Tantobie, S.O., County Durham	S. Dec. 9, 1893
		A. Aug. 3, 1901
		M. Aug. 2, 1902
763	SWAN, HENRY FREDERICK, Walker Shipyard, Newcastle-upon-Tyne	Sept. 2, 1871
764	SWETE, OSWALD RICKETTS, Argosy Mine, Ngobevu, *via* Greytown, Natal, South Africa	June 9, 1906
765	SWINBURNE, UMFREVILLE PERCY, Inspector of Mines, Pretoria, Transvaal	A.M. Aug. 4, 1894
		M. June 14, 1902
766	SWINDLE, JACKSON, Swalwell, S.O., County Durham	June 14, 1902
767	SWINNEY, ALFRED JOHN GEORGE, Lorne Villa, Elm Road, Sidcup, S.O., Kent	June 11, 1898
768	SYMONS, FRANCIS, Ulverston	Feb. 11, 1899
769	TALLIS, ALFRED SIMEON, The Rhyd, Tredegar	April 9, 1904
770	TALLIS, JOHN FOX, The Firs, Ebbw Vale, S.O., Monmouthshire	Dec. 12, 1903
771	TATE, SIMON, Trimdon Grange Colliery, County Durham (*Member of Council*)	Sept. 11, 1875
772	TATE, WALKER OSWALD, Grange Hill, Bishop Auckland	S. Oct. 12, 1895
		A. Aug. 1, 1903
		M. Feb. 13, 1904
773	TAYLOR, ALFRED HENRY, Puponga Colliery, Collingwood, Nelson, New Zealand	Dec. 14, 1901
774	TAYLOR, THOMAS, Chipchase Castle, Wark, S.O., Northumberland	July 2, 1872
775	TEASDALE, THOMAS, Middridge, Heighington, S.O., County Durham	April 9, 1892
776	TELFORD, WILLIAM HAGGERSTONE, Hedley Hope Collieries, Tow Law, S.O., County Durham	S. Oct. 3, 1874
		A.M. Aug. 6, 1881
		M. June 8, 1889
777	TENNANT, JOHN THOMAS, James Street, Hamilton, Newcastle, New South Wales, Australia	Dec. 12, 1903
778	TERRY, ARTHUR MICHAEL, 23, Claremont Place, Gateshead-upon-Tyne	Aug. 6, 1904
779	THOM, ARCHIBALD, Jun., Moresby Parks, near Whitehaven	Aug. 5, 1905
780	THOMAS, ARTHUR, Chilecito, Province Rioja, Argentine Republic, South America	Aug. 7, 1897
781	THOMAS, ERNEST HENRY, Oakhill, Gadlys, Aberdare	Feb. 10, 1900

		Date of Election and of Transfer.
782	THOMAS, ILTYD EDWARD, Glanymor, Swansea	Feb. 10, 1900
783	THOMAS, J. J., Hawthorn Villa, Kendal	June 21, 1894
784	THOMAS, RICHARD, Cambria Villa, Stockton, New South Wales, Australia	Feb. 11, 1899
785	THOMLINSON, WILLIAM, Seaton Carew, West Hartlepool ...	April 25, 1896
786	THOMPSON, ALFRED, Talbot House, Birtley, S.O., County Durham	Dec. 13, 1902
787	THOMPSON, CHARLES LACY, Farlam Hall, Brampton Junction, Carlisle	A.M. Feb. 10, 1883 M. Aug. 3, 1889
788	THOMPSON, JOHN G., Bank House, Collins Green, Earlestown, Newton-le-Willows	June 8, 1895
789	THOMPSON, JOHN WILLIAM, East Holywell Colliery, Shiremoor, Newcastle-upon-Tyne	A. June 10, 1893 M. Feb. 10, 1900
790	THOMPSON, WILLIAM, 1 and 2, Great Winchester Street, London, E.C.	Aug. 4, 1888
791	THOMSON, JOHN, Eston Mines, by Middlesbrough	April 7, 1877
792	THOMSON, JOHN WHITFIELD	Oct. 11, 1902
793	THORNTON, NORMAN MUSCHAMP, Seaton Burn and Dinnington Collieries, Seaton Burn, Dudley, S.O., Northumberland	S. April 27, 1895 A. Aug. 2, 1902 M. June 10, 1903
794	TINSLEY, JAMES, Bridge House, Ebbw Vale, S.O., Monmouthshire	Dec. 12, 1903
795	TODD, JOHN THOMAS, Blackwell Collieries, Alfreton ...	S. Nov. 4, 1876 A.M. Aug. 1, 1885 M. June 8, 1889
796*	TOWNSEND, HARRY POYSER, c o New Kleinfontein Company, Limited, P.O., Benoni, Transvaal	April 12, 1902
797	TRELEASE, WILLIAM HENWOOD, Via dei Cattaneo, Novara, Italy: and Ceppomorelli per Macugnaya, Vall' Anzasca, Prov. di Novara, Italy	April 8, 1893
798	TREVOR, EARLE WELLINGTON JENKS, c o Nonex Safety Tank Company, 46, Dover Street, Piccadilly, London, W. ...	Aug. 2, 1902
799	TROTMAN, HENRY LEIGH, Moorland House, Aspull, Wigan	Feb. 13, 1904
800	TULIP, SAMUEL, Bunker Hill, Fence Houses	June 12, 1897
801	TURNBULL, JOHN JAMES, 30, Park Avenue, Whitley Bay, S.O., Northumberland	Feb. 12, 1898
802	TURNBULL, ROBERT, Usworth Colliery, Washington, S.O., County Durham	Aug. 2, 1902
803	TUXEN, PETER VILHELM, 60, Market Street, Melbourne, Victoria, Australia	April 7, 1906
804	TWEDDELL, GEORGE HERBERT, "Edenholme," Beverley Gardens, Cullercoats, Whitley Bay, S.O., Northumberland	Feb. 13, 1904
805	TYERS, JOHN EMANUEL, Rewah State Collieries, Umaria, Central India	A.M. Dec. 10, 1877 M. Aug. 3, 1889
806	TYRRELL, JOSEPH BURR, 87, Binscarth Road, Toronto, Canada	Feb. 10, 1900
807	TYZACK, DAVID, Bellingham, S.O., Northumberland ...	Feb. 14, 1874
808	UPTON, PRESCOTT, P.O. Box 1026, Johannesburg, Transvaal	June 12, 1897
809	VARTY, THOMAS, Skelton Park Mines, Skelton-in-Cleveland, S.O., Yorkshire	Feb. 12, 1887
810	VAUGHAN, CEDRIC, Hodbarrow Iron-ore Mines, Millom, S.O., Cumberland	Dec. 10, 1892
811	VEASEY, HARVEY C., "Tetulmoorie," Sijua P.O., Manbhum District, Bengal, India	June 21, 1894
812	VERNY, GEORGE	Oct. 8, 1898
813	VERSCHOYLE, WILLIAM DENHAM, Tanrago, Ballisodare, S.O., County Sligo	Dec. 11, 1897
814	WADHAM, WALTER FRANCIS AINSLIE, Millwood, Dalton-in-Furness, S.O., Lancashire	Dec. 10, 1898
815	WALES, HENRY THOMAS, Western Mail Chambers, Cardiff	Feb. 11, 1893

Date of Election and of Transfer.

816 WALKER, HENRY BLAIR, Cassell Coal Company, Springs, Transvaal ... ... Oct. 9, 1897
817 WALKER, JAMES HOWARD, Bank Chambers, Wigan ... Dec. 9, 1899
818 WALKER, JOHN SCARISBRICK, Pagefield Iron Works, Wigan ... ... Dec. 4, 1869
819 WALKER, SYDNEY FERRIS, Ellangowan, Taunton Road, Ashton-under-Lyne ... ... June 11, 1898
820 WALKER, THOMAS A., Pagefield Iron Works, Wigan ... June 8, 1895
821 WALKER, WILLIAM EDWARD, Lowther Street, Whitehaven Nov. 19, 1881
822 WALL, HENRY, Rowbottom Square, Wallgate, Wigan ... June 8, 1895
823 WALL, WILLIAM HENRY, 748, Burrard Street, Vancouver, British Columbia ... ... June 14, 1902
824 WALLWORK, JESSE, Drywood, Worsley, Manchester ... Feb. 9, 1895
825 WALSH, GEORGE PATON, 564, Heirengracht, Amsterdam, Holland ... ... Nov. 24, 1894
826 WALTON, JONATHAN COULTHARD, Writhlington Colliery, Radstock, Bath ... ... S. Nov. 7, 1874 A.M. Aug. 6, 1881 M. June 8, 1889
827 WALTON, WILLIAM HENRY, Bridgewater Offices, Walkden, Manchester ... ... June 10, 1903
828 WARD, ALEXANDER HOUSTONNE, Raneegunge, Bengal, India April 14, 1894
829* WARD, THOMAS HENRY, Giridih, E.I.R., Bengal, East India A.M. Aug. 5, 1882 M. Aug. 3, 1889
830 WATERS, STEPHEN, Apartado No. 96, Pachuca, Mexico ... April 4, 1903
831 WATKYN-THOMAS, WILLIAM, Workington ... ... A.M. Feb. 10, 1883 M. Aug. 3, 1889
832 WATSON, CLAUDE LESLIE, The Bengal Coal Company, Limited, Raneegunge, E.I.R., Bengal, India ... ... Dec. 8, 1900
833 WATSON, EDWARD, c/o Spassky Zabod, Akmolinsk, Siberia S. Feb. 13, 1892 M. Aug. 4, 1894
834 WATSON, THOMAS, Trimdon Colliery, S.O., County Durham Oct. 11, 1890
835 WATTS, J. WHIDBOURNE, P.O. Box 179, Barberton, Transvaal ... ... Dec. 12, 1896
836 WEBSTER, ALFRED EDWARD, Manton, Worksop ... ... June 12, 1897
837 WEDDERBURN, CHARLES MACLAGAN, 8, East Fettes Avenue, Edinburgh ... ... Oct. 14, 1905
838 WEED, WALTER HARVEY, U.S. Geological Survey, Washington, D.C., U.S.A. ... ... June 14, 1902
839 WEEKS, JOHN GEORGE, Bedlington, S.O., Northumberland (PAST-PRESIDENT, *Member of Council*) ... ... Feb. 4, 1865
840 WEEKS, RICHARD LLEWELLYN, Willington, S.O., County Durham (*Member of Council*) ... ... A.M. June 10, 1882 M. Aug. 3, 1889
841* WEINBERG, ERNEST ADOLPH, 39, Queen Street, Melbourne, Victoria, Australia ... ... A.M. Feb. 12, 1898 M. Oct. 8, 1898
842 WELSH, THOMAS, Brynhyfryd, Cilfynydd, Pontypridd ... Feb. 14, 1903
843 WELTON, WILLIAM PITT, Santa Ana, Departamento del Tolima, Republic of Colombia, South America ... ... Dec. 9, 1905
844 WELTON, WILLIAM SHAKSPEARE, Elm Road, Wembley, S.O., Middlesex ... ... Dec. 14, 1901
845 WESTERN, CHARLES ROBERT, Queen Anne's Mansions, Westminster, London, S.W. ... ... June 10, 1893
846 WESTMACOTT, PERCY GRAHAM BUCHANAN, Rose Mount, Sunninghill, Ascot ... ... June 2, 1866
847 WHITE, CHARLES EDWARD, Wellington Terrace, South Shields S. Nov. 4, 1876 A.M. Aug. 1, 1885 M. Aug. 3, 1889
848 WHITE, FREDERICK NAPIER, H.M. Inspector of Mines, 12, St. James' Gardens, Swansea ... ... June 11, 1898
849 WHITE, HENRY, Walker Colliery, Newcastle-upon-Tyne ... S. March 2, 1867 M. Aug. 5, 1871
850 WIDDAS, C., North Bitchburn Colliery, Howden, Darlington ... ... Dec. 5, 1868
851 WIDDAS, HENRY, Beechburn Grange, Howden-le-Wear, S.O., County Durham ... ... April 7, 1906

		Date of Election and of Transfer.
852	Widdas, Percy, Oakwood, Cockfield, S.O., County Durham	Aug. 6, 1904
853	Wight, Edward Septimus, Taupiri Coal-mines, Limited, Mine-manager's Office, Huntly, near Auckland, New Zealand	A.M. Dec. 12, 1885 M. Aug. 3, 1889
854	Wight, Frederick William, 5, Bondicar Terrace, Blyth	Aug. 5, 1905
855	Wight, Robert Tennant, Hallbankgate, Milton, Carlisle	Oct. 13, 1900
856	Wilbraham, Arthur George Bootle, Mina de San Domingos, Mertola, Portugal	S. Dec. 11, 1897 M. Feb. 8, 1902
857	Wilkins, William Glade, Westinghouse Building, Pittsburg, Pennsylvania, U.S.A.	Dec. 11, 1897
858	Wilkinson, John Thomas, Black Hills Road, Horden Colliery, Castle Eden, S.O., County Durham	Dec. 8, 1900
859*	Wilkinson, William Fischer, 2, Queen Anne's Gate, Westminster, London, S.W.	Oct. 10, 1896
860	Williams, Alpheus Fuller, De Beers Consolidated Mines, Limited, Kimberley, South Africa	Oct. 12, 1901
861	Williams, Gardner Frederick, De Beers Consolidated Mines, Limited, Kimberley, South Africa	Oct. 12, 1895
862	Williams, Griffith John, H.M. Inspector of Mines, Bangor	Aug. 2, 1902
863	Williams, Henry J. Carnegie, Bruce Mines, Algoma, Ontario, Canada	Oct. 12, 1895
864	Williams, John, Dolavon, Llanrwst, S.O., Denbighshire	Oct. 8, 1904
865	Williams, John Richard, P.O. Box 149, Johannesburg, Transvaal	June 11, 1904
866	Williams, James Wilson, 15, Valley Drive, Harrogate	April 4, 1903
867	Williams, Luke, Claremont, Moonah, Tasmania	April 10, 1897
868	Williams, Robert, 50, Clements Lane, Lombard Street, London, E.C.	June 13, 1896
869	Willis, Henry Stevenson, Medomsley, S.O., County Durham	S. Feb. 13, 1892 A. Aug. 4, 1900 M. June 8, 1907
870	Wilson, Anthony, Thornthwaite, Keswick	A.M. Feb. 10, 1900 M. Dec. 13, 1902
871	Wilson, Archibald Laurence, The New Ravenswood, Limited, Ravenswood, Queensland, Australia	A.M. June 12, 1897 M April 2, 1898
872	Wilson, James, Wellington House, Edmondsley, Chester-le-Street	April 13, 1901
873	Wilson, Joseph R., 606-607, Commonwealth Building, Twelfth and Chesnut Streets, Philadelphia, Pennsylvania, U.S.A.	Oct. 12, 1895
874	Wilson, Lloyd, Flimby Colliery, Maryport	Jan. 19, 1895
875	Wilson, Nathaniel, East Rand Proprietary Mines, Limited, Mechanical Engineering Department, P.O. Box 56, East Rand, Transvaal	Dec. 9, 1899
876	Wilson, Peregrine Oliver, c/o F. F. Wilson, 7, Devonshire Square, Bishopsgate Street, London, E.C.	Dec. 9, 1893
877	Wilson, Robert Gott, Battle Green, Pelton Fell Colliery, Chester-le-Street	A. Aug. 6, 1892 M. Dec. 12, 1903
878	Wilson, William Brumwell, Horden Dene, Easington, Castle Eden, S.O., County Durham	S. Feb. 6, 1869 M. Aug. 2, 1873
879*	Wilson, William Brumwell, Jun., Usworth Colliery, Washington, S.O., County Durham	Feb. 9, 1901
880	Winchell, Horace V., c/o Great Northern Railway Company, St. Paul, Minnesota, U.S.A.	Nov. 24, 1894
881	Winstanley, Robert, 42, Deansgate, Manchester	Sept. 7, 1878
882	Witt, Otto, Aktiebolaget Mahmanrikning, Falun, Sweden	April 9, 1904
883	Wood, Ernest Seymour, Dawdon Colliery, Seaham Harbour, Sunderland	Oct. 10, 1891
884	Wood, John, Coxhoe Hall, Coxhoe, S.O., County Durham	S. June 8, 1889 A. Aug. 4, 1894 M. Aug. 3, 1895
885*	Wood, Sir Lindsay, Bart., The Hermitage, Chester-le-Street (Past-President, *Member of Council*)	Oct. 1, 1857
886	Wood, Richard, P.O. Box 5550, Johannesburg, Transvaal	June 14, 1902

		Date of Election and of Transfer.
887	Wood, Robert, 8, Olympia Gardens, Morpeth	April 13, 1907
888	Wood, Thomas, North Hetton Colliery Office, Moorsley, Hetton-le-Hole, S.O., County Durham	S. Sept. 3, 1870 M. Aug. 5, 1871
889	Wood, Thomas Outterson, East Cramlington, Cramlington, S.O., Northumberland	Feb. 14, 1903
890	Wood, William Henry, Coxhoe Hall, Coxhoe, S.O., County Durham	Aug. 6, 1857
891	Wood, William Outterson, South Hetton, S.O., County Durham (Past-President, *Member of Council*)	Nov. 7, 1863
892	Woodburne, Thomas Jackson, Bultfontein Mine, De Beers Consolidated Mines, Limited, Kimberley, South Africa	Feb. 10, 1894
893	Woodeson, William Armstrong, Clarke, Chapman and Company, Limited, Victoria Works, Gateshead-upon-Tyne	Dec. 10, 1904
894	Wormald, Charles Frederick, Mayfield Villa, Saltwell, Gateshead-upon-Tyne	A.M. Dec. 8, 1883 M. Aug. 3, 1889
895	Wright, Abraham, East Indian Railway, Engineering Department, Giridih, Bengal, India	Feb. 11, 1905
896	Wrightson, Sir Thomas, Bart., Stockton-upon-Tees ...	Sept. 13, 1873
897	Yeoman, Thomas Pressick, Government Collieries, Warora, Central Provinces, India	Aug. 1, 1903
898	Yerbury, Frederick Augustus, Hernosand, Esher Avenue, Walton-on-Thames	Oct. 13, 1906
899	Youll, Gibson, Bulli, New South Wales, Australia ...	Oct. 12, 1901
900	Young, Harben Robert, P.O. Box 78, Potchefstroom, Transvaal	Feb. 9, 1901
901	Young, James, 4, Granville Road, Jesmond, Newcastle-upon-Tyne	Oct. 9, 1897
902	Young, John Andrew, 3, Fountain Avenue, Gateshead-upon-Tyne	A.M. Dec. 10, 1887 M. Aug. 3, 1889
903	Young, John Huntley, Wearmouth Colliery, Sunderland	June 21, 1894

ASSOCIATE MEMBERS (Assoc. M.I.M.E.).

Marked * have paid life composition.

		Date of Election and of Transfer.
1	Ainsworth, George, The Hall, Consett, S.O., County Durham	Dec. 9, 1905
2	Alder, William, 3, Beech Avenue, Whitley Bay, S.O., Northumberland	Oct. 12, 1901
3	Armstrong, John Hobart, St. Nicholas' Chambers, Newcastle-upon-Tyne	Aug. 1, 1885
4	Aspinall, John Eccles, Post Office, Roodepoort, Transvaal	Feb. 13, 1904
5	Atkinson, Alfred, Clarke, Chapman and Company, Limited, Victoria Works, Gateshead-upon-Tyne	April 13, 1901
6	Atkinson, George Blaxland, Prudential Assurance Buildings, Mosley Street, Newcastle-upon-Tyne ...	Nov. 5, 1892
7	Barrett, William Scott, Abbotsgate, Blundellsands, Liverpool	Oct. 14, 1899
8	Beauchamp, Frank B., Woodborough House, near Bath ...	Oct. 8, 1904
9*	Bell, Sir Hugh, Bart., Middlesbrough	Dec. 9, 1882
10	Bird, Edward Erskine, c/o George Elliot and Company, Limited, 16, Great George Street, Westminster, London, S.W.	Aug. 5, 1905
11	Bishop, Clarence Adrian, Engineering and Building Works, Mooi River, Natal, South Africa	Oct. 10, 1903
12	Broadbent, Arthur Cecil, Royal Societies Club, St. James' Street, London, S.W.	Feb. 9, 1901

Date of Election and of Transfer.

13*Broadbent, Denis Ripley, Royal Societies Club, St. James' Street, London, S.W. *Transactions* sent to The Library, Royal Societies Club, St. James' Street, London, S.W. — Oct. 14, 1899
14 Brutton, P. M., 17, Sandhill, Newcastle-upon-Tyne .. — Oct. 13, 1900
15 Burdon, Augustus Edward, Hartford, Bedlington, S.O., Northumberland ... ... — Feb. 10, 1883
16 Burn, Charles William, 28, Fawcett Street, Sunderland — June 11, 1898

17 Cackett, James Thoburn, Pilgrim House, Newcastle-upon-Tyne ... ... — Oct. 10, 1903
18 Capell, Rev. George Marie, Passenham Rectory, Stony Stratford ... ... — Oct. 8, 1892
19*Carr, William Cochran, Benwell Colliery, Newcastle-upon-Tyne ... ... — Oct. 11, 1890
20 Chambers, David Macdonald, 23, St. Mary's Mansions, Paddington, London, W. ... ... — Oct. 8, 1904
21*Chewings, Charles, 85, Edward Street, Norwood, South Australia ... ... — April 25, 1896
22 Cochrane, Ralph D., Hetton Colliery Offices, Fence Houses. *Transactions* sent to W. Cochrane, Willington Colliery Office, Willington, S.O., County Durham ... ... — June 1, 1878
23 Cooper, R. W., Newcastle-upon-Tyne ... ... — Sept. 4, 1880
24 Cope, William Henry, The University, Birmingham ... — Dec. 9, 1905
25 Cory, Clifford John, c/o Cory Brothers and Company, Limited, Cardiff ... ... — Dec. 11, 1897
26 Cruttenden, William Courtenay Dawes, 31A, Colmore Row, Birmingham ... ... — June 11, 1904

27 Eastwood, William, 93, Scar Lane, Milnsbridge, Huddersfield ... ... — Dec. 8, 1906
28 Eccles, Edward, King Street, Newcastle-upon-Tyne ... — Oct. 13, 1894
29 Edwards, F. Henry, Bath Lane, Newcastle-upon-Tyne ... — June 11, 1887
30 Ellam, Albert Spencer, c/o Mexican Concessions, Limited, 138, Leadenhall Street, London, E.C. .. — April 25, 1896
31 Ellis, Oswald William, 49, Beaumont Fee, Lincoln ... — Oct. 11, 1902

32 Fairless, Joseph, Mineral Traffic Manager, North Eastern Railway Company, Newcastle-upon-Tyne ... ... — June 10, 1899
33 Ferguson, C. A., P.O. Box 21, Randfontein, Transvaal ... — July 14, 1896
34 Foster, T. J., Coal Exchange, Scranton, Pennsylvania, U.S.A. ... ... — Dec. 12, 1891

35 George, Edward James, Beech Grove, Consett, S.O., County Durham ... ... — Dec. 9, 1905
36 Gibson, Thomas William, Bureau of Mines, Toronto, Ontario, Canada ... ... — June 8, 1901
37*Graham, John, Findon Cottage, Sacriston, Durham ... — Oct. 9, 1897
38 Graham, James Parmley, 26, Cloth Market, Newcastle-upon-Tyne ... ... — Dec. 8, 1906
39 Gunn, Scott, 18, John Street, Sunderland ... ... — Aug. 1, 1903
40 Guthrie, Reginald, Neville Hall, Newcastle-upon-Tyne (Treasurer, *Member of Council*) ... ... — Aug. 4, 1888

41 Haanel, Eugene, Department of Interior, Ottawa, Ontario, Canada ... ... — Aug. 1, 1903
42 Hall, Charles, 196, Gresham House, London, E.C. ... — Dec. 9, 1905
43 Hampson, Benjamin Atherton, Hampson's Collieries, Dingley Dale, *via* Waschbank, Natal, South Africa ... — Aug. 5, 1905
44 Harris-Edge, H. P., Coalport Works, Shifnal ... .. — June 8, 1901
45 Haswell, William Spence, Beverley Gardens, Cullercoats, Whitley Bay, S.O., Northumberland ... ... — April 13, 1901
46 Hedley, John Hunt, John Street, Sunderland ... ... — June 13, 1891
47 Helley, George, East Avenue, Benton, Newcastle-upon-Tyne ... ... — Dec. 14, 1895

Date of Election and of Transfer.

48 HENDERSON, CHARLES WILLIAM CHIPCHASE. c o John George Weeks, Bedlington, S.O., Northumberland ... Dec. 9, 1882
49 HENZELL, ROBERT, Northern Oil Works, Newcastle-upon-Tyne ... ... April 11, 1891
50 HILDRED, WILLOWS, 43, Voltaire Road, Clapham, London, S.W. ... ... June 9, 1900
51 HODGETTS, ARTHUR, c o A. H. Thornton, "Overdale," Washwood Heath Road, Birmingham ... ... Oct. 9, 1897
52 HOPPER, JOHN INGLEDEW, Wire-rope Works, Thornaby-upon-Tees ... ... Dec. 8, 1888
53 HUMPHREYS-DAVIES, GEORGE, 5, Laurence Pountney Lane, Cannon Street, London, E.C. ... ... Oct. 8, 1892

54 INNES, THOMAS SNOWBALL, Crown Chambers, Side, Newcastle-upon-Tyne ... ... Dec. 10, 1898

55 JAMES, HENRY M., Colliery Office, Whitehaven ... ... June 10, 1893
56 JEANS, JAMES STEPHEN, 165, Strand, London, W.C. ... April 2, 1898
57 JEFFREY, JOSEPH ANDREW, c o The Jeffrey Manufacturing Company, Columbus, Ohio, U.S.A. ... ... Dec. 11, 1897
58 JEFFRIES, JOSHUA, Hartley Street, Lambton, New South Wales, Australia ... ... Dec. 10, 1898
59*JOICEY, JAMES JOHN, 62, Finchley Road, London, N.W. ... Oct. 10, 1891

60 KIDSON, ARTHUR, c o Glaholm and Robson, Limited, Rope Manufacturers, Sunderland ... ... April 8, 1899
61 KROHN, HERMAN ALEXANDER, 103, Cannon Street, London, E.C. ... ... Oct. 14, 1893

62 LAMB, EDMUND GEORGE, Borden Wood, Liphook, S.O., Hants. ... ... Feb. 12, 1898
63 LAMBERT, THOMAS, Town Hall Buildings, Gateshead-upon-Tyne ... ... Aug. 2, 1902
64 LANGSLOW-COCK, EDWARD ARTHUR, H.M. Inspector of Mines, Mine Office, Seremban, Negri Sembilan, Federated Malay States ... ... Aug. 2, 1902
65 LATIMER, WILLIAM, 3, St. Nicholas' Buildings, Newcastle-upon-Tyne ... ... Oct. 14, 1905
66 LISHMAN, GEORGE PERCY, Bunker Hill, Fence Houses ... Aug. 4, 1900
67 LOEWENSTEIN, HANS VON LOEWENSTEIN ZU, Friedrichstrasse, 2, Essen-Ruhr, Germany. *Transactions* sent to Bibliothek des Vereins für die bergbaulichen Interessen im Oberbergamtsbezirk Dortmund, Essen-Ruhr, Germany April 13, 1907

68 MARSHALL, PATRICK, University School of Mines, Dunedin, New Zealand ... ... June 12, 1897
69 MATCHETT, RICHARD JOHN, 12, Hatton Terrace, Ilford ... Oct. 14, 1905
70 MORRIS, PERCY COPELAND, 79, Elm Park Gardens, London, S.W. ... ... Feb. 14, 1903

71 ORMROD, WILSON, Union Buildings, St. John Street, Newcastle-upon-Tyne ... ... Feb. 9, 1907

72 PALMER, ALFRED MOLYNEUX, John Bowes and Partners, Limited, Milburn House, Newcastle-upon-Tyne ... Nov. 24, 1894
73 PICKERING, HENRY, 13, South Parade, Whitley Bay, S.O., Northumberland ... ... Dec. 9, 1905
74*PICKUP, P. W. D., Rishton Colliery, Rishton, Blackburn ... Feb. 12, 1898
75 POSTLETHWAITE, JOHN, Chalcedony House, Eskin Place, Keswick ... ... Feb. 11, 1905
76 PRIOR-WANDESFORDE, RICHARD HENRY, Castlecomer House, Castlecomer, S.O., County Kilkenny ... ... Dec. 9, 1905
77*PROCTOR, JOHN HENRY, 45, Percy Gardens, Tynemouth, North Shields ... ... June 8, 1889

		Date of Election and of Transfer.
78	QUINCE, WILLIAM JOHN, P.O. Box 297, Pietermaritzburg, Natal, South Africa	April 8, 1905
79	REDMAYNE, ROBERT NORMAN, Woodside, Low Fell, Gateshead-upon-Tyne	Dec. 8, 1906
80	REID, SIDNEY, Printing Court Buildings, Newcastle-upon-Tyne	Dec. 13, 1902
81	RIDLEY, JAMES CARTMELL, 1, Bentinck Terrace, Newcastle-upon-Tyne	Feb. 11, 1893
82	ROGERSON, JOHN EDWIN, Oswald House, Durham	June 8, 1895
83	ROSEN, JOHN, P.O. Box 1647, Johannesburg, Transvaal ...	Dec. 10, 1898
84	RUSSELL, JAMES, Westgate Road, Newcastle-upon-Tyne ...	Feb. 13, 1904
85	SADLER, BASIL, Craigmore, Lanchester, Durham	Feb. 11, 1905
86	SAMUEL, DAVID, Ynyswen, New Road, Llanelly	Dec. 13, 1902
87	SANDERS, CHARLES WILLIAM HENRY, Sherburn House, near Durham	Dec. 14, 1901
88	SAUNDERS, GEORGE B., Saunders, Todd and Company, Maritime Buildings, King Street, Newcastle-upon-Tyne ...	Jan. 19, 1895
89	SCHUMACHER, RAYMOND WILLIAM, c/o H. Eckstein and Company, P.O. Box 149, Johannesburg, Transvaal ...	April 9, 1904
90	SCOTT, JOHN OLIVER, Milburn House, Newcastle-upon-Tyne	Dec. 11, 1897
91	SMITH, ARTHUR HERBERT, Broad Street House, London, E.C.	June 14, 1902
92	STEUART, DOUGLAS STUART-SPENS, Royal Societies Club, St. James' Street, London, S.W.	June 10, 1899
93	STRANGE, HAROLD FAIRBROTHER, P.O. Box 590, Johannesburg, Transvaal	Dec. 11, 1897
94	TODD, JAMES, Overdale, Jesmond, Newcastle-upon-Tyne ...	Aug. 6, 1892
95	TUNNINGTON, ALBERT, Barberton Far East Gold-mining Syndicate, Limited, Far East Siding, P.O., Hectors Spruit, Transvaal	Oct. 9, 1897
96	TURNER, CHARLES EDWARD, Mina Campanario, Valverde del Camuio, Provincia de Huelva, Spain	Aug. 6, 1898
97	VALENTINE, JAMES, 1, West View, Horwich, S.O., Lancashire	June 14, 1902
98	VOSKUIL, GIDEON A., The Transvaal Gold-fields, Limited, P.O. Box 550, Johannesburg, Transvaal	Dec. 10, 1904
99	WALEY, FREDERICK GEORGE, The Bellambi Coal Company, Limited, 9, Bridge Street, Sydney, New South Wales, Australia	Feb. 9, 1907
100	WALKER, FREDERICK TILLOTSON, 70, Pilgrim Street, Newcastle-upon-Tyne	June 10, 1903
101	WALL, GEORGE YOUNG, Halmote Court Office, New Exchequer Building, Durham	Nov. 24, 1894
102	WALMESLEY, OSWALD, 2, Stone Buildings, Lincoln's Inn, London, W.C.	June 8, 1895
103	WELFORD, THOMAS, Wallarah Colliery, Catherine Hill Bay, New South Wales, Australia	June 10, 1903
104	WHITEHEAD, THOMAS, Brindle Lodge, Preston	June 12, 1897
105	WILLIAMS, HENRY, Llwyngwern, Pontardulais, S.O., Glamorgan	Dec. 9, 1905
106	WOOD, ARTHUR NICHOLAS LINDSAY, The Hermitage, Chester-le-Street	July 14, 1896
107	WRIGHTSON, WILFRID INGRAM, Neasham Hall, Darlington	Dec. 9, 1899
108	YOUNG, MRS. H. E., c/o Hon. H. E. Young, Parliament Buildings, Victoria, British Columbia	April 4, 1903

ASSOCIATES (Assoc. I.M.E.).

Marked * have paid life composition.

		Date of Election and of Transfer.
1	ALLAN, HERBERT DURHAM, Rewah State Collieries, Umaria, Central India, Bengal Nagpur Railway	Feb. 10, 1906
2	ALLPORT, EDWARD ASTON, Lound House, Haxey, Doncaster	S. April 14, 1894 A. Aug. 4, 1900
3	ARCHER, MATTHEW WILLIAM, High Priestfield, Lintz Green, County Durham	S. June 8, 1895 A. Aug. 4, 1900
4	ARMSTRONG, HENRY, South View House, Greenhill, Murton Colliery, *via* Sunderland	Dec. 12, 1903
5	ARMSTRONG, WILLIAM, Jun., Cramlington Colliery, Cramlington, S.O., Northumberland	S. June 11, 1898 A. Aug. 6, 1904
6	ASKEW, ALFRED HILL, 16, Telford Street, Gateshead-upon-Tyne	Feb. 9, 1907
7	ATKINSON, BERTRAM, Newburgh Colliery, Acklington, S.O., Northumberland	Aug. 6, 1904
8	BAMBOROUGH, JACOB, Preston Colliery, North Shields ...	Oct. 8, 1904
9	BATES, JOHNSON, 5, Grange Villa, Chester-le-Street ...	Feb. 11, 1905
10	BATTEY, THOMAS, Station Road, Shiremoor, Newcastle upon-Tyne	Oct. 13, 1894
11	BAYLDON, HAROLD CRESSWELL, Broad Street House, London, E.C.	S. April 2, 1898 A. Aug. 3, 1901
12	BELL, HAROLD PERCY, Brookwell House, Gilcrux, Bullgill, S.O., Cumberland	S. Aug. 2, 1902 A. Aug. 4, 1906
13	BELL, WILLIAM, Plashetts, S.O., Northumberland	S. Feb. 13, 1897 A. Aug. 6, 1904
14	BENSON, HERBERT SYDNEY, Shield Row Hall, Stanley, S.O., County Durham	S. Feb. 11, 1905 A. Aug. 5, 1905
15	BEWICK, GEORGE, Johnson Terrace, West Auckland, Bishop Auckland	April 10, 1897
16	BEWLEY, THOMAS, 11, Curtis Road, Fenham, Newcastle-upon-Tyne	Aug. 5, 1905
17	BLAIR, ROBERT, 6, Hamilton Terrace, Whitehaven	Aug. 2, 1902
18	BLANDFORD, THOMAS, Tresavean Mines, Limited, Lanner, Redruth	S. Dec. 12, 1903 A. Aug. 3, 1907
19	BOOTH, FREDERIC LANCELOT, Ashington Colliery, Morpeth	S. Feb. 10, 1894 A. Aug. 4, 1900
20	BOWES, THOMAS, Pontop House, Annfield Plain, S.O., County Durham	Feb. 13, 1892
21	BRANDON, GEOFFRY, 9, Kensington Gardens, Monkseaton, Whitley Bay, S.O., Northumberland	S. Dec. 8, 1900 A. Aug. 3, 1907
22	BROWN, EDWARD OTTO FORSTER, Springfort, Stoke Bishop, Bristol	S. Dec. 14, 1901 A. Aug. 3, 1907
23	BURT, THOMAS, Hill House, Washington, Washington Station, S.O., County Durham	April 9, 1904
24	CARROLL, JOHN, Spring Bank House, Newfield, Willington, S.O., County Durham	Feb. 12, 1898
25	CHARLTON, WILLIAM JOHN, Jun., 17, First Row, Ashington, Morpeth	April 12, 1902
26	CHEESMAN, MATTHEW FORSTER, Throckley Colliery, Newburn, S.O., Northumberland	S. Dec 13, 1902 A. Aug. 5, 1905
27	CHURCH, ROBERT WILLIAM, c/o T. Cook and Son, Bombay, India	S. Dec. 9, 1905 A. Aug. 3, 1907
28	CLARK, NATHANIEL J., Belle Vue, Chester-le-Street ...	S. April 13, 1901 A. Aug. 1, 1903
29	CLARK, THOMAS, Dipton Colliery, Lintz Green Station, County Durham	Oct. 11, 1890
30	CLIFFORD, EDWARD HERBERT, Rand Club, Johannesburg, Transvaal	S. Oct. 13, 1894 A. Aug. 6, 1898
31	CLIVE, ROBERT, Bentley Colliery, near Doncaster	S. Feb. 10, 1900 A. Aug. 1, 1903

		Date of Election and of Transfer.
32	Clough, Edward Stokoe, Bomarsund House, Bomarsund, Bedlington, S.O., Northumberland	Feb. 14, 1903
33	Clough, John, 1, Melton Terrace, Seaton Delaval, S.O., Northumberland	Feb. 13, 1897
34	Coade, Samuel, Steel Green, Millom, S.O., Cumberland ...	Dec. 10, 1904
35	Cockbain, Tom Stewartson, Usworth Colliery, Washington Station, S.O., County Durham	Dec. 8, 1906
36	Cockburn, John, Fatfield Road, Washington, S.O., County Durham	April 9, 1904
37	Cockburn, William, Railway Terrace, New Lambton, Fence Houses	Dec. 9, 1905
38	Cook, George, Binchester Hall, Bishop Auckland	S. Aug. 2, 1902 A. Aug. 5, 1905
39	Cowell, Edward, Shotton Colliery Offices, Shotton Colliery, Castle Eden, S.O., County Durham	Oct. 8, 1904
40	Cowx, H. F., Hilly View, Thornley, S.O., County Durham	April 14, 1894
41	Coxon, Samuel George, Station View, Esh Winning, Durham	Feb. 9, 1901
42	Coxon, William Bilton, South View, Crook, S.O., County Durham	S. Feb. 12, 1898 A. Aug. 2, 1902
43	Crawford, Thomas, The Croft, Wrekenton, Gateshead-upon-Tyne	Dec. 8, 1906
44	Crofton, Charles Arthur, Wansbeck Colliery Company, Limited, Morpeth	S. Dec. 10, 1898 A. Aug. 1, 1903
45	Crombie, Robert. Hollin Hurst House, Rowlands Gill, Newcastle-upon-Tyne	Dec. 9, 1905
46	Crowle, Percy, 51, Mainsgate Road, Millom, S.O., Cumberland...	Feb. 11, 1905
47	Cummings, John, Hamsterley Colliery, Ebchester, S.O., County Durham	Aug. 2, 1902
48	Danskin, Thomas, Springwell Colliery, Gateshead-upon-Tyne	Dec. 10, 1898
49	Davis, James E., South Medomsley Colliery, Dipton, S.O., County Durham	Feb. 12, 1898
50	Davison, Francis, 37, Hedley Hill Terrace, Waterhouses, Durham	Feb. 12, 1898
51	Dick-Cleland, Archibald Felce, Ria Ora, Trelawny Road, Camborne	Dec. 8, 1906
52	Dixon, George, 14, Queens Square, Eastwood, Nottingham	S. Feb. 9, 1901 A. Aug. 3, 1907
53	Dunnett, Samuel, West View House, Coomassie Road, Waterloo, Blyth	June 8, 1895
54	Eadie, John Allan, Jun., Blaydon Burn Colliery, Blaydon-upon-Tyne, S.O., County Durham	S. Oct. 10, 1903 A. Aug. 5, 1905
55	Elliott, Christopher, 11, Front Street, East Stanley, Stanley, S.O., County Durham	Feb. 11, 1905
56	Elves, Edward, Sherburn Colliery, Durham	June 13, 1896
57	Emmerson, George. Oakenshaw Colliery, Willington, S.O., County Durham	Oct. 8, 1898
58	English, Thomas Weddle, Halton Colliery, Whittington, Corbridge, S.O., Northumberland...	Feb. 11, 1905
59	Eskdale, John, Ashington Colliery, Morpeth	Oct. 11, 1902
60	Falcon, Michael, Llanarth Villas, Cross Keys, Newport, Monmouthshire	S. Oct. 13, 1894 A. Aug. 4, 1900
61	Field, Benjamin Starks, 6, South View, Annfield Plain, S.O., County Durham	S. Aug. 2, 1902 A. Aug. 3, 1907
62	Foggo, John Frederick, West View, Scotland Gate. Morpeth	S. June 14, 1902 A. Aug. 6, 1904
63	Ford, Thomas, Blaydon Burn Colliery, Blaydon-upon-Tyne, S.O., County Durham	Aug. 2, 1902

Date of Election and of Transfer.

64 FORSTER, EDWARD BATY, 15, Grange Road, Ryton, S.O., County Durham ... ... April 7, 1906

65 FORSTER, FRANK, Black Hills Road, Horden Colliery, Castle Eden, S.O., County Durham ... ... Feb. 8, 1902

66 FOWLER, ROBERT NORMAN, Staindrop House, Station Road, New Washington, Washington Station, S.O., County Durham ... ... S. Aug. 2, 1902 A. Aug. 3, 1907

67 GALLAGHER, PATRICK, Clifton Row, Netherton Colliery, Nedderton, Newcastle-upon-Tyne... ... ... Dec. 13, 1902

68 GALLOWAY, JOHN, Hebburn Colliery, Hebburn, S.O., County Durham ... ... S. Dec. 13, 1902 A. Aug. 4, 1906

69 GIDNEY, WILLIAM HENRY, 9, Ravensbourne Terrace, South Shields ... ... S. April 13, 1901 A. Aug. 3, 1907

70 GLASS, ROBERT WILLIAM, Axwell Park Colliery, Swalwell, S.O., County Durham ... ... S. June 10, 1899 A. Aug. 1, 1903

71 GORDON, GEORGE STOKER, 24, Louisa Terrace, Stanley, S.O., County Durham ... ... Feb. 15, 1896

72 GORE-LANGTON, ROBERT LANCELOT, c/o T. Caplin, Manganese Mines, Chipumpalle, Vizagapatam District, India ... ... Feb. 10, 1906

73 GRAHAM, CECIL, 4, Rockcliff, Whitley Bay, S.O., Northumberland ... ... S. April 4, 1903 A. Aug. 1, 1903

74 GREENWELL, ALAN LEONARD STAPYLTON, Windlestone Colliery, Ferry Hill ... ... S. Oct. 8, 1898 A. Aug. 5, 1905

75 GREENWELL, GEORGE HAROLD, Herbert Villa, Mountenoy Road, Rotherham ... ... S. Dec. 12, 1903 A. Aug. 4, 1906

76 GREY, JOHN NEIL, 20, St. Mary's Terrace, Ryton, S.O., County Durham ... ... June 10, 1905

77 GUY, JOHN GEORGE, Manor House, Wardley Colliery, Newcastle-upon-Tyne ... ... Dec. 8, 1906

78 HALL, JOSEPH PERCIVAL, Edmondsley Colliery, Chester-le-Street ... ... S. Oct. 9, 1897 A. Aug. 2, 1902

79 HAMPSON, ALEXANDER, St. Helen's Colliery, Bishop Auckland ... ... Feb. 12, 1898

80 HANDYSIDE, WILLIAM, Jun., 4, Brandling Terrace, Felling, S.O., County Durham ... ... June 12, 1897

81 HARE, GEORGE, Seghill Colliery, Seghill, Dudley, S.O., Northumberland ... ... Feb. 12, 1898

82 HARPER, GEORGE OCTAVIUS, Greenhead, Chopwell Colliery, Lintz Green, County Durham ... ... S. Feb. 8, 1902 A. Aug. 3, 1907

83 HAWES, GEORGE ARTHUR, 29, Dene Terrace, Murton Colliery, *viâ* Sunderland ... ... Dec. 12, 1903

84 HEAPS, CHRISTOPHER, 12, Richmond Terrace, Gateshead-upon-Tyne ... ... S. Feb. 10, 1900 A. Aug. 4, 1906

85 HEDLEY, GEORGE WILLIAM, Alexander Terrace, Coach Lane Houses, Dinnington Colliery, Dudley, S.O., Northumberland ... ... Dec. 13, 1902

86 HENDERSON, WILLIAM, 4, Beatrice Terrace, New Herrington, Philadelphia, Fence Houses ... ... Oct. 12, 1901

87 HERRIOTTS, JOSEPH GEORGE, Shampore Colliery, Nirshachatti P.O., *viâ* Barakar, E.I.R., Bengal, India ... April 28, 1900

88 HERRON, EDWARD, 4, Holly Terrace, Stanley, S.O., County Durham ... ... Feb. 15, 1896

89 HESLOP, WILLIAM, High Grange, Howden-le-Wear, S.O., County Durham ... ... Oct. 8, 1898

90 HORNSBY, DEMSTER, Choppington Colliery, Scotland Gate, Morpeth ... ... Feb. 12, 1898

91 HUDSON, MARK, 115, Gurney Valley, Bishop Auckland ... Dec. 9, 1905

92 HUGHES, THOMAS, Fan Terrace, Urpeth Busty, Birtley, S.O., County Durham ... ... Feb. 10, 1906

93 HUMBLE, ERNEST, Lawson Street, Hamilton, Newcastle, New South Wales, Australia ... ... S. Feb. 14, 1903 A. Aug. 3, 1907

		Date of Election and of Transfer.
94	HUMBLE, JOHN NORMAN, West Pelton House, Beamish, S.O., County Durham	S. Aug. 2, 1902 A. Aug. 5, 1905
95	HUNTER, ANDREW, 2, Abbotsford Terrace, South Shields ...	Feb. 13, 1897
96	IMRIE, HENRY MARSHALL, 22, Western Hill, Durham ...	Feb. 14, 1903
97	JEFFERY, ALBERT JOHN, 8, Agents Terrace, Boldon Colliery, S.O., County Durham	April 28, 1900
98	JOHNSON, THOMAS, 3, Granville Terrace, Binchester Blocks, Bishop Auckland	Dec. 9, 1905
99	JOHNSON, WILLIAM, Framwellgate Moor, Durham	Aug. 6, 1892
100	JUNOR, PATRICK BRUCE, Jun., 32, Durdham Park, Bristol	S. April 12, 1902 A. Aug. 3, 1907
101	KELLETT, ROBERT	Feb. 12, 1898
102	KIRBY, MATTHEW ROBSON, c/o Addison Laughorne Steavenson, Holywell Hall, Durham	S. June 9, 1900 A. Aug. 1, 1903
103	LIDDELL, CHRISTOPHER, Houghton Main Colliery, near Barnsley	S. Dec. 14, 1901 A. Aug. 6, 1904
104	LIGHTLEY, JOHN, Byers Green, Spennymoor	April 25, 1896
105	LOGAN, REGINALD SAMUEL MONCRIEFF, 20, Boyd Terrace, Blucher Pit, Newburn, S.O., Northumberland	S. Feb. 9, 1901 A. Aug. 1, 1903
106	LONGRIDGE, JOHN, Castlecomer, S.O., County Kilkenny ..	Feb. 11, 1905
107	MCCARTHY, MICHAEL DODDS, 61, Mitchell Street, Birtley, S.O., County Durham	Dec. 14, 1901
108	MCDONALD, FRANCIS, 164, Leadgate, S.O., County Durham	Oct. 13, 1906
109	MCGREGOR, JOHN EDWARD, 28, Clifford Road, Stanley, S.O., County Durham	S. April 4, 1903 A. Aug. 1, 1903
110	MARLEY, FREDERICK THOMAS, Sitalpore Colliery, Dishagarh, Barakar, E. I. R., Bengal, India	S. Oct. 8, 1898 A. Aug. 5, 1905
111	MARSHALL, JOHN JOSEPH	April 9, 1904
112	MASON, BENJAMIN, Burnopfield Colliery, Burnopfield, S.O., County Durham	April 11, 1891
113	MELVILLE, JOHN THOMAS, 4, Poplar Gardens, Gosforth, Newcastle-upon-Tyne	April 8, 1899
114	MERIVALE, CHARLES HERMAN, Middleton Estate and Colliery Company, Middleton, Leeds	S. June 9, 1900 A. Aug 6, 1904
115	MILBURN, EDWIN WALTER, Trevelyan House, Ashington, Morpeth	S. Feb. 10, 1900 A. Aug. 5, 1905
116	MILBURN, WILLIAM, Hill House, Ouston, Chester-le-Street	June 8, 1895
117	MILBURNE, JOHN ETHERINGTON, Stobswood Colliery, Acklington, S.O., Northumberland	S. Oct. 14, 1899 A. Aug. 6, 1904
118	MILLER, ALEXANDER, South Greta Colliery, near West Maitland, New South Wales, Australia	Oct. 10, 1903
119	MINNS, THOMAS TATE, Jun., Binchester Blocks, Bishop Auckland	S. April 10, 1897 A. Aug. 1, 1903
120	MINTO, GEORGE WILLIAM, Harraton Colliery, Chester-le-Street	Oct. 10, 1891
121*	MITCHELL-WITHERS, WILLIAM CHARLES, P.O. Box 2969, Johannesburg, Transvaal	S. April 28, 1900 A. Aug. 2, 1902
122	MORLAND, THOMAS, New Herrington, Philadelphia, Fence Houses	Feb. 11, 1899
123	MORSON, FARRER WILLIAM, Glenholm, Crook, S.O., County Durham	Aug. 4, 1900
124	MUSGROVE, WILLIAM, Heddon Colliery, Northumberland...	S. June 8, 1895 A. Aug. 1, 1903
125	NAISBIT, JOHN, No. 48, Tudhoe Colliery, Spennymoor ...	April 27, 1895
126	NELSON, GEORGE CATRON, Greenhead Terrace, Chopwell Colliery, Ebchester, S.O., County Durham	Feb. 8, 1902
127	NESBIT, JOHN STRAKER, Marley Hill Colliery, Swalwell, S.O., County Durham	S. Oct. 9, 1897 A. Aug. 5, 1905

Date of Election and of Transfer.

128 Oswald, George Robert, c/o The Labuan Coal-fields Company, Limited, Borneo. All communications to be sent to E. William Oswald, 14, Victoria Road, Whitehaven ... ... — S. June 9, 1900; A. Aug. 3, 1907

129 Owen, William Rowland, The Sangli Gold-mines, Limited, Gadag, Bombay Presidency, India ... ... — Feb. 12, 1898

130 Parkin, Thomas Wakefield, 17, Gowland Terrace, Wheatley Hill Colliery, Thornley, S.O., County Durham — Feb. 8, 1902

131 Parrington, Henry Mason, Hill House, Monkwearmouth, Sunderland ... ... — S. Feb. 13, 1904; A. Aug. 3, 1907

132 Parrington, Thomas Elliott, Hill House, Monkwearmouth, Sunderland ... ... — S. Aug. 3, 1895; A. Aug. 1, 1903

133 Pattison, Andrew, Greenside, Ryton, S.O., County Durham — Dec. 8, 1906

134 Pattison, Charles Arthur, High Grange, Howden-le-Wear, S.O., County Durham ... ... — S. April 13, 1901; A. Aug. 5, 1905

135 Pattison, William, Horsley House, East Stanley, Stanley, S.O., County Durham ... ... — Dec. 13, 1902

136 Pearson, John Charlton, Swiss Cottage, Westerhope, Newcastle-upon-Tyne ... ... — Feb. 14, 1903

137 Pedelty, Simon, Broomhill Colliery, Acklington, S.O., Northumberland ... ... — Dec. 10, 1892

138 Peel, George, Jun., 27, Langley Street, Langley Park, Durham ... ... — April 4, 1903

139 Phelps, Charles, c/o Darby and Company, Sandakan, British North Borneo ... ... — Aug. 3, 1901

140 Potts, Laurance Wylam, The Leam, Felling, S.O., County Durham ... ... — April 4, 1903

141 Pratt, George Ross, Springwell Colliery, Gateshead-upon-Tyne ... ... — June 8, 1895

142 Proctor, Thomas, Woodhorn Colliery, Morpeth ... ... — Oct. 13, 1894

143 Pumphrey, Charles Ernest, Minster Acres, Riding Mill, S.O., Northumberland ... ... — S. Dec. 10, 1904; A. Aug. 4, 1906

144 Ramsay, John Gladstone, Page Bank Colliery, Spennymoor — Dec. 10, 1892

145 Richardson, Benjamin, 29, Westcott Terrace, Deanbank, Ferry Hill ... ... — April 7, 1906

146 Richardson, Henry, Clara Vale Colliery, Ryton, S.O., County Durham ... ... — Dec. 8, 1906

147 Ridley, George D., 7, Stanley Crescent, Whitley Bay, S.O., Northumberland ... ... — Feb. 8, 1890

148 Ridley, William, Jun., Mary Pit, Blaydon-upon-Tyne, S.O., County Durham ... ... — Dec. 8, 1906

149 Ridpath, Tom R., Medomsley, S.O., County Durham ... — S. June 8, 1901; A. Aug. 4, 1906

150 Rivers, John, Bow Street, Thornley Colliery, Durham .. — Feb. 9, 1895

151 Robinson, John William, Callerton, Kenton, Newcastle-upon-Tyne ... ... — Dec. 13, 1902

152 Robinson, John William, 3, Victoria Terrace, East Boldon, S.O., County Durham ... ... — S. April 12, 1902; A. Aug. 5, 1905

153 Rochester, William, 1, Office Row, Netherton Colliery, Nedderton, Newcastle-upon-Tyne ... ... — Dec. 9, 1905

154 Rochester, William, Ryton Barmoor, Ryton, S.O., County Durham ... ... — Dec. 10, 1898

155 Rochester, William Simm, 3, Victoria Terrace, Hamsterley, Ebchester, S.O., County Durham ... ... — Feb. 13, 1904

156 Rogers, John, 1, The Avenue, Murton Colliery, *via* Sunderland ... ... — S. April 8, 1899; A. Aug. 4, 1906

157 Rolfe, Robert, Middle Friarside, Burnopfield, S.O., County Durham ... ... — Dec. 9, 1905

158 Roose, Hubert F. G., Royal School of Mines, South Kensington, London, S.W. ... ... — S. Dec. 9, 1899; A. Aug. 3, 1907

159 Rutherford, Thomas Easton, West Shield Row Colliery, Stanley, S.O., County Durham ... ... — S. June 10, 1899; A. Aug. 4, 1906

		Date of Election and of Transfer.
160	SANER, CHARLES B., Turf Mines, Limited, P.O. Box 5887, Johannesburg, Transvaal	April 10, 1897
161	SCHOLLICK, THOMAS, 13, Model Street, New Seaham, Sunderland	Dec. 12, 1903
162	SCOBIE, ISAAC, Woonona, near Sydney, New South Wales, Australia	Oct. 13, 1906
163	SEED, ALEXANDER, 1, College Terrace, Brandon Colliery, S.O., County Durham	April 4, 1903
164	SEVERS, JONATHAN, Stanley, S.O., County Durham ...	S. June 8, 1895 A. Aug. 4, 1900
165	SIMPSON, RICHARD CHARLTON, Wellington Terrace, Edmondsley, Chester-le-Street	Feb. 13, 1904
166	SMALLWOOD, PERCY EDMUND, Garesfield Colliery, High Spen, Newcastle-upon-Tyne	Oct. 11, 1902
167	SNOWDON, THOMAS, Jun., Oakwood, Cockfield, S.O., County Durham	S. June 12, 1897 A. Aug. 3, 1901
168	SOUTHERN, STEPHEN, Heworth Colliery, Felling, S.O., County Durham	S. Dec. 14, 1895 A. Aug. 3, 1901
169	STOBART, THOMAS CARLTON, Ushaw Moor Colliery, Durham	Aug. 2, 1902
170	STOKER, NICHOLAS, South Pelaw Colliery, Chester-le-Street	Feb. 13, 1904
171	STOKOE, JOHN GEORGE, Station Road, Birtley, S.O., County Durham	Dec. 9, 1899
172	SUMMERBELL, RICHARD, Preston Colliery, North Shields ...	Dec. 9, 1905
173	SWAN, WILLIAM EDWARD, Washington Colliery, Co. Durham	April 9, 1904
174	SWANN, JOSEPH TODD, Falmouth House, Throckley, Newburn, S.O., Northumberland	S. Dec. 13, 1902 A. Aug. 4, 1906
175	TATE, ROBERT SIMON, Black Boy Colliery, Bishop Auckland	S. Aug. 3, 1901 A. Aug. 4, 1906
176	TAYLOR, HERBERT WILLIAM, El Bote Mine, Zacatecas, Mexico	Aug. 2, 1902
177	TURNBULL WILLIAM, West Holywell, Backworth Colliery, Newcastle-upon-Tyne	Oct. 8, 1904
178	TURNER, GEORGE, Tindale Terrace, Roachburn Colliery, Brampton Junction, Carlisle	June 8, 1895
179	TWEDDELL, GEORGE, 51, Double Row, Seaton Delaval, S.O., Northumberland	June 8, 1907
180	TWEDDELL, JOHN SMITH, Seaton Delaval Colliery, Northumberland	S. Feb. 13, 1897 A. Aug. 1, 1903
181	URWIN, JOHN	Feb. 15, 1896
182	URWIN, THOMAS, Dipton Colliery, Lintz Green, County Durham	Feb. 14, 1903
183	WAINWRIGHT, WILLIAM, Heworth Colliery, Felling, S.O., County Durham	April 2, 1898
184	WALTON, ARTHUR JOHN, Bettisfield Colliery, Bagillt, S.O., Flintshire	S. Feb. 12, 1898 A. Aug. 1, 1903
185	WALTON, HARRY, Durham Road, Consett, S.O., County Durham	Dec. 10, 1904
186	WARDLE, ROBERT, Edgewell Terrace, Prudhoe, Ovingham, S.O., Northumberland	April 13, 1907
187	WELSH, ARTHUR, Red House, Tunstall Village, near Sunderland	S. Aug. 1, 1896 A. Aug. 1, 1903
188	WHITFIELD, THOMAS CUTHBERT, Trimdon Grange Colliery, County Durham	Oct. 8, 1904
189	WIDDAS, FRANK, Orchard House, Escombe, Bishop Auckland	Dec. 8, 1900
190	WILKINSON, MAURICE HEWSON...	Dec. 12, 1903
191	WILSON, CHRISTOPHER, 40, Morris Street, Birtley, S.O., County Durham	Feb. 11, 1905
192	WILSON, HUGH, 18, Grange Villa, Chester-le-Street... ...	Feb. 13, 1904

Date of Election and of Transfer.

193 YIELDER, HUGH LISHMAN, 14, Moor View, Ryton, S.O., County Durham ... ... April 7, 1906
194 YOUNG, GEORGE ELLIS, Findon Hill, Sacriston, Durham ... S. Aug. 3, 1901
A. Aug. 5, 1905

STUDENTS (Stud.I.M.E.).

Date of Election.

1 ANNETT, HUGH CLARKSON, Widdrington, Acklington, S.O., Northumberland ... ... Feb. 15, 1906

2 BARRETT, ROLLO SAMUEL, Whitehill Hall, Chester-le-Street ... Dec. 9, 1905
3 BRYDON, ANDREW DEMPSTER, Elmhurst, Wellington Road, Camborne, Cornwall ... ... Dec. 8, 1906

4 CALLAND, WILLIAM, Hedley Hope Collieries, Tow Law, S.O., County Durham ... ... April 7, 1906

5 DOUGLAS, ALBERT EDWARD, Beethoven House, Horden, Castle Eden, S.O., County Durham ... . Aug. 1, 1903

6 ELLIOT, ARTHUR, 13, Eldon Place, Newcastle-upon-Tyne ... Dec. 13, 1902

7 GILCHRIST, GEORGE ATKINSON, 17, Eldon Place, Newcastle-upon-Tyne ... ... Dec. 14, 1901
8 GRACE, WILLIAM GRACE, Hall Garth Hall, Winlaton, Blaydon-upon-Tyne, S.O., County Durham ... ... Feb. 9, 1907
9 GRAHAM, WILLIAM, Jun., Solway House, Moresby, Whitehaven Oct. 13, 1906
10 GULLACHSEN, BERENT CONRAD, Hotel Norge, Bergen, Norway April 8, 1905

11 HAWKINS, JOHN BRIDGES BAILEY, Staganhoe Park, Welwyn ... Dec. 13, 1902
12 HEDLEY, ROWLAND FRANK HUTTON, Langholme, Roker, Sunderland ... ... April 4, 1903
13 HESLOP, WARDLE, Westfield, Benwell, Newcastle-upon-Tyne ... Dec. 10, 1904
14 HUGGUP, RALPH, 1, Bentinck Place. Newcastle-upon-Tyne ... Feb. 10, 1906
15 HUNTER, HERBERT STANLEY, Blakelaw, Kenton. Newcastle-upon-Tyne ... ... Feb. 9, 1907
16 HUTTON, ALLAN ROBINSON BOWES, Peases West Collieries, Crook, S.O., County Durham ... ... April 8, 1905

17 JONES, WALTER, c/o Mrs. Fenwick, The Farm, Wheatley Hill Colliery, Thornley, S.O., County Durham ... ... Feb. 9, 1901

18 LAWSON, RICHARD FORSTER, Daisy Hill, Edmondsley, Chester-le-Street ... ... Feb. 13, 1904
19 LIDDELL, HENRY NORMAN JOHN, Grange Road, Ryton, S.O., County Durham ... ... June 10, 1905
20 LISTER, JOHN ALFRED, Linden House, Carlton Terrace, Spennymoor ... ... Dec. 8, 1906

21 MACGREGOR, DONALD, Seghill Colliery. Seghill, Dudley, S.O., Northumberland ... ... Feb. 9, 1901
22 MUSE, THOMAS JOHN, Jun., Cornsay Colliery, Durham ... ... Dec. 8, 1906

23 NABLE, FELICIANO, 17, Hazelwood Avenue, Jesmond, Newcastle-upon-Tyne ... ... Dec. 9, 1905
24 NICHOLSON, GEORGE THOMPSON, Dene House, Scotswood, S.O., Northumberland ... ... Dec. 10, 1904

25 OLIVER, ERNEST HUNTER, Denewell Avenue, Low Fell, Gateshead-upon-Tyne ... ... Feb. 8, 1902

Date of Election.

26 Palmer, Harry, The Manor House, Medomsley, S.O., County Durham ... ... June 14, 1902
27 Palmer, Meyrick, The Manor House, Medomsley, S.O., County Durham ... ... June 8, 1901

28 Richardson, Frank, Stratford House, East Boldon, S.O., County Durham ... ... Oct. 12, 1901
29 Ritson, John Anthony Sydney, Burnhope Colliery, Lanchester, Durham ... ... Aug. 4, 1906
30 Robinson, Claud Alleyne, The Chesnuts, Bolton-le-Sands, Carnforth ... ... Aug. 5, 1905
31 Robinson, Stanley, Bunker Hill, Fence Houses ... ... Oct. 12, 1901

32 Sharp, Charles Gordon, Riding Mill, S.O., Northumberland ... Feb. 10, 1906
33 Simpson, Joseph, Wheatley Hill Colliery Office, Thornley, S.O., County Durham ... ... June 10, 1905
34 Slater, Thomas Edward, Blaydon Burn Colliery, Blaydon-upon-Tyne, S.O., County Durham ... ... April 13, 1907
35 Smith, Ernest Arthur, 5, Bath Terrace, Seaham Harbour, Sunderland ... ... Dec. 9, 1905
36 Southern, Charles, Heworth Colliery, Felling, S.O., County Durham ... ... June 10, 1903
37 Strong, George Adamson, 2, West View, Low Eighton, Low Fell, Gateshead-upon-Tyne ... ... Aug. 2, 1902

38 Thirlwell, Thomas A., 18, Lynwood Avenue, Bentinck Road, Newcastle-upon-Tyne ... ... Dec. 13, 1902
39 Thompson, George Heron Dinsdale, Dinsdale Vale, Windsor Avenue, Waterloo, Blyth ... ... Feb. 14, 1903
40 Thornton, Frank, Cornsay Colliery, Durham ... ... Feb. 8, 1902

41 Walker, Joseph Noel, 33, Sherburn Terrace, Consett, S.O., County Durham ... ... Aug. 6, 1904
42 Weeks, Francis Mathwin, 3, Catherine Road, Surbiton, Surrey Feb. 10, 1906
43 Welch, William Hall, 49, Mitchell Street, Birtley, S.O., County Durham ... ... Feb. 10, 1906
44 Wild, Robert Powley, Applegarth, Queens Road, Cheltenham Dec. 8, 1906
45 Wilkinson, Ralph Percy, Burnmoor Lodge, Fence Houses ... Dec. 9, 1905
46 Wraith, Alfred Osborn, 73, Lyons Terrace, Hetton-le-Hole, S.O., County Durham ... ... June 9, 1900
47 Wraith, Charles Osborn, Thornley Colliery Office, Thornley, S.O., County Durham ... ... June 10, 1905

SUBSCRIBERS.

1 Owners of Ashington Colliery, Newcastle-upon-Tyne.
2 Birtley Iron Company (3), Birtley, S.O., County Durham.
3 The Broken Hill Proprietary Company, Limited, 3, Great Winchester Street, London, E.C.
4 Brunner, Mond and Company, Limited, Northwich.
5 The Most Honourable the Marquess of Bute. Bute Estate Offices, Aberdare.
6 Butterknowle Colliery Company. Darlington.
7 The Charlaw and Sacriston Collieries Company, Limited, 34, Grey Street, Newcastle-upon-Tyne.
8 Cowpen Coal Company, Limited (2), F, King Street, Newcastle-upon-Tyne.
9 The Honourable Lord Ninian Edward Crichton-Stuart, House of Falkland, Falkland, S.O., Fifeshire. All *Transactions* and Correspondence sent to c o J. and F. Anderson, 48, Castle Street, Edinburgh.
10 Dominion Coal Company, Limited, Glace Bay, Nova Scotia.
11 The Right Honourable the Earl of Durham (2), Lambton Offices, Fence Houses.

12 The Right Honourable the Earl of Ellesmere (2), Bridgewater Offices, Walkden, Manchester. *Transactions* sent to Jno. Henry V. Hart-Davis, Bridgewater Offices, Walkden, Manchester.
13 Elswick Coal Company, Limited, Newcastle-upon-Tyne.
14 D. H. and G. Haggie, Wearmouth Patent Rope Works, Sunderland.
15 Harton Coal Company, Limited (3), Harton Collieries, South Shields.
16 Hetton Coal Company (5), Fence Houses.
17 James Joicey and Company, Limited (2), Newcastle-upon-Tyne.
18 Lameton Collieries, Limited (2), E, Queen Street, Newcastle-upon-Tyne.
19 The Most Honourable the Marquess of Londonderry (5), c/o Vincent Charles Stuart Wortley Corbett, Londonderry Offices, Seaham Harbour.
20 Mavor and Coulson, Limited, 47, Broad Street, Mile-End, Glasgow.
21 North Brancepeth Coal Company, Limited, Crown Street Chambers, Darlington.
22 Owners of North Hetton Colliery (3), Fence Houses.
23 Osbeck and Company, Pit Timber Merchants, Newcastle-upon-Tyne.
24 Rand Mines, Limited, The Corner House, Johannesburg, Transvaal.
25 Ryhope Coal Company (2), Ryhope Colliery, Sunderland.
26 Owners of Seghill Colliery, Seghill, Dudley, S.O., Northumberland.
27 Siemens Brothers and Company, Limited, 39, Collingwood Buildings, Newcastle-upon-Tyne.
28 Société Houillère de Liévin (Pas-de-Calais), Liévin, Pas-de-Calais, France.
29 Owners of South Hetton and Murton Collieries (2), 50, John Street, Sunderland.
30 Owners of Stella Colliery, Hedgefield, Blaydon-upon-Tyne, S.O., County Durham.
31 Owners of Throckley Colliery, Newcastle-upon-Tyne.
32 Owners of Victoria Garesfield Colliery, Victoria Garesfield Colliery, Lintz Green, Co. Durham. *Transactions* sent to H. Peile, Priestman's Collieries, Limited, Milburn House, Newcastle-upon-Tyne.
33 Owners of Wearmouth Colliery (2), Sunderland.
34 Westport Coal Company, Limited (2). Dunedin, New Zealand.

ENUMERATION.

August 3, 1907.

Honorary Members	21
Members	903
Associate Members	108
Associates	194
Students	47
Subscribers	34
Total	1,307

Members are desired to communicate all changes of address, or any corrections or omissions in the list of names, to the Secretary.

BRIEF SYLLABUS

OF THE

THREE YEARS' COURSE OF LECTURES

FOR

COLLIERY ENGINEERS, ENGINEWRIGHTS, APPRENTICE MECHANICS AND OTHERS.

The Council of The North of England Institute of Mining and Mechanical Engineers, in collaboration with the Council of Armstrong College, have arranged a course of Lectures for Colliery Engineers, Enginewrights, Apprentice Mechanics and others, to be delivered at Armstrong College, Newcastle-upon-Tyne.

The course will extend over three winter sessions, and involves attendance for about 24 Saturday afternoons, from 3 p.m. to 5 p.m. or from 4 p.m. to 6 p.m., during each session. Students can enter any of the courses, each series of Lectures being, as far as possible, entirely independent of the others, and constituting a complete course upon its own subject.

Students entering on the three years' course of Lectures, must possess a knowledge of Arithmetic, Algebra and Mensuration, including the following:—(*a*) Arithmetic: the ordinary rules of arithmetic, including simple proportion and vulgar and decimal fractions. (*b*) Algebra: as far as simple equations, including square and cube roots; and a knowledge of the power of a number, such as x^3 or x^4. (*c*) The use of logarithmic tables. (*d*) Mensuration: areas of rectangles and of triangles; areas and circumferences of circles; surfaces of cylinders; and contents or volumes of cylinders and prisms.

It is desirable that Students should not be less than 17 years of age.

The delivery of the next course of Lectures will commence on October 5th, 1907. The fee for the series of four courses given during each session is £1 10s.

Examinations will be held at the end of each course in the respective subjects. Certificates will be granted to those Students who attend satisfactorily and pass the Examinations throughout the three years' course, and Prizes will be awarded annually to the two Students who do best in the aggregate Examinations of the year.

The Council recommend that colliery owners and others, who send Students to these classes, should insist upon home work being done regularly.

Certificates have been awarded to the following Students who have completed the three years' course:—Messrs. G. H. Bell, T. H. Mitchell and J. T. Pringle. Messrs. M. Halliday and S. Cadwallender, who gained the highest aggregate number of marks, have divided first and second prizes for the session 1906-1907.

A number of colliery owners have agreed to pay the fees and (or) train fares of some of their employees whom they propose to send to the course of Lectures.

Any further information will be supplied on application to Mr. F. H. Pruen, Secretary, Armstrong College, Newcastle-upon-Tyne, or Mr. M. Walton Brown, Secretary, The North of England Institute of Mining and Mechanical Engineers, Neville Hall, Newcastle-upon-Tyne.

MICHAELMAS TERM, Commencing on October 5th, 1907.

The Steam-engine.—3·0 to 3·50 p.m.

Lecturer—Mr. J. Morrow, M.Sc., D.Eng.

Heat, its measurement and transfer; saturated steam; pressure and temperature of steam; expansion of steam; the indicator and indicator-diagrams; horse-power, indicated and effective; simple forms of the steam-engine, valves and the distribution of steam, governors; compound and triple-expansion engines; efficiency of the steam-engine; steam-boilers, combustion and draught; evaporative power of coal.

Theoretical Electricity.—4·5 to 4·55 p.m.

Lecturer—Mr. H. Morris-Airey, M.Sc.

Magnetism; lines of magnetic force, magnetic field; distinctive magnetic properties of iron and steel. Electricity; production of an electric current; magnetic, chemical and heating effects of the current; measurement of current strength, electro-motive force and resistance; practical electrical units, the ampère, volt and ohm; Ohm's Law. The principle of the dynamo and the electric motor.

EPIPHANY TERM, Commencing on January 11th, 1908.

Electrical Engineering.—4·0 to 4·55 p.m.

Lecturer—Prof. W. M. Thornton, D.Sc., M.I.E.E.

Systems of measurement, current, voltage, resistance, practical instruments, magnetic induction, continuous-current dynamos, details of construction, motors, methods of connecting and testing dynamos and motors, alternating currents, incandescent and arc lamps, secondary cells, mains, cables, wiring of buildings and mines, applications of electric-motive power in mining.

Haulage and Winding.—5·10 to 6·0 p.m.

Lecturer—Prof. Henry Louis, M.A., A.R.S.M.

Main haulage-roads, animal traction, self-acting inclines, engine-planes, main-and-tail-rope haulage, endless-rope or endless-chain haulage; haulage-engines, plant and appliances, underground haulage-engines; electric, hydraulic and pneumatic engines; secondary haulage. Onsetting and banking. Winding-engines, cages, ropes, safety appliances, pulley-frames, headsteads, surface arrangements.

1908-1909.—MICHAELMAS TERM.

Transmission of Power.

Lecturer—Mr. J. Morrow, M.Sc., D.Eng.

Work and power; different forms of energy, its storage, transformation and transmission; simple machines, friction and lost work, efficiency of machinery; methods of transmitting power, shafting and bearings, spur-and-bevel wheels, rope gearing, hydraulic transmission, compressed-air transmission; the steam-engine and boiler; comparison of different methods.

Pumping and Ventilation.

Lecturer—Prof. Henry Louis, M.A., A.R.S.M.

Elementary notions of drainage, dams, reservoirs; syphons; baling; arrangement of pumps, driving, starting and working pumps; pipes; bucket-pumps; plunger-pumps; details, balance-bobs, angle-bobs, spears, catches, etc.; pump-valves; direct-acting pumps; electric, pneumatic and hydraulic pumps.

Principles of ventilation; movement of air-currents; measurement of air-currents, anemometers, water-gauges; natural ventilation; ventilating appliances, fans, furnaces; distribution of air-currents, splitting currents, doors, stoppings, regulators; general considerations affecting ventilation.

1908-1909.—EPIPHANY TERM.

Metallurgy of Iron and Steel.

Lecturer—Mr. H. Dean, A.R.S.M.

The nature of the raw materials used in the manufacture of iron and steel. Chemical composition of coal and other fuels. The phenomena of combustion. Gaseous fuel and gas-producers. Fire-resisting materials. The ores of iron. The blast-furnace; conversion of pig-iron into wrought-iron and steel. The puddling process and the various methods of steel making. The structure and nature of steel; hardening and tempering.

Mining Machinery (mainly Machinery used Underground).

Lecturer—Prof. Henry Louis, M.A., A.R.S.M.

Methods of conveying power underground, comparison of methods: compressed air, electricity, water, steam, ropes. Air-compressors, simple and stage compressors. Diagrams. Valve construction. Cooling. Receivers and fittings. Pipes. Percussion and rotary rock-drills and their construction. Dynamos and motors used for underground operations. Sparking and its dangers. Leads. Rock-drills. Coal-cutting machinery of various types. Heading-machines. Underground hauling, winding and pumping engines. Miscellaneous applications.

1909-1910.—MICHAELMAS TERM.

Machine Drawing.

Lecturer—Mr. E. M. Eden.

Representation on a drawing, by plan, elevation and section, of a solid object, for example, the simpler parts of machines and structures. Fastenings, comprising bolts and nuts, rivets, cotters and keys. Bearings, pistons, cross-heads and connecting-rods. Stop-valves, slide-valves, wheels and pulleys. Reasons for various forms of construction; and calculation of proportions of some of the simpler parts.

The Chemistry of Fuel.

Lecturer—Mr. F. C. Garrett, D.Sc., F.C.S.

Nature of fuels in general. The chemistry of carbon and its oxides. Natural and artificial fuels, gaseous fuels, gas-producers. Calorific power and calorific intensity of fuel. Pyrometry.

1909-1910.—EPIPHANY TERM.

Strength of Materials (with Experimental Illustrations).

Lecturer—Mr. E. M. Eden.

Materials used in construction:—Cast-iron, wrought-iron, steel, brass, brick. Stress and strain. Strength under tension, compression, shearing and bending. Breaking and working strengths; factors of safety; the effect of live loads; extension and compression under loads; behaviour of material under stress; effect of length of specimens.

The lectures will be illustrated by actual experiments on the 100 tons testing-machine in the Engineering Laboratory.

Experimental Mechanics.

Lecturer—Mr. H. Morris-Airey, M.Sc.

Introductory definitions, with illustrations; force and work, and their measurement; power; horsepower; principle of the conservation of energy. Machines for changing the magnitude and the direction of force; workshop appliances, lever, single and double purchase winches, pulleys, inclined plane and screw, screwjack; friction, efficiency of machines. Graphical representation of forces. Specific gravity and its determination by the hydrostatic balance. The atmosphere and the pressure it exerts; the barometer; lifting and forcing pumps.

LIST OF TRANSACTIONS AND JOURNALS OF SOCIETIES, ETC., IN THE LIBRARY.

*Académie Royale des Sciences, des Lettres et des Beaux-Arts de Belgique, Brussels. Annuaire, complete from 1882. Bulletin, complete from vol. iii.
‡Acetylene Association, London. Proceedings, complete.
Acts of Parliament.
Africa. Records of South-eastern Africa, by George McCall Theal. Complete.
African Review, London. Complete from vol. ix., 1896, to vol. xli., 1904.
‡African World, London. Complete from vol. i., 1902.
*American Academy of Arts and Sciences, Boston. Memoirs, complete from vol. i., 1873. Proceedings, complete from vol. i., 1846.
‡American Engineer and Railroad Journal, New York City. Vol. lxvii., 1893 (incomplete); vol. lxviii., 1894; vol. lxix., 1895 (incomplete); and complete from vol. lxxv., 1901, no. 12.
‡American Gas Light Journal, New York City. Complete from vol. lxxv., 1901, no. 22.
‡American Institute of Electrical Engineers, New York City. Transactions, complete from vol. xviii., 1901.
*American Institute of Mining Engineers, New York City. Bulletin, nos. 1 and 2. Transactions, complete from 1871.
‡American Machinist, London. Complete from vol. xvii., 1894.
American Manufacturer and Iron World, Pittsburg. Complete from vol. lxx., 1902, to vol. lxxviii., 1906.
*American Philosophical Society, Philadelphia. Proceedings, complete from vol. xl., 1901.
*American Society of Civil Engineers, New York City. Proceedings, complete from vol. i., 1873. Transactions, complete from vol i., 1872.
*American Society of Mechanical Engineers, New York City. Transactions, complete from 1880.
*Annales des Mines, Paris. Journal, complete, except vols. xxxi. to xxxviii. Mémoires, complete, except series 1, 2, 3 and 4. Lois, Décrets, etc., complete, except series 1, 2, 3 and 4, and series 7, vol. i., and pages 149 to end of vol. v.
†Annales des Mines de Belgique, Brussels. Mémoires, complete.
Annales des Ponts et Chaussées, Paris. Mémoires et Documents, complete from series 6, vol. i., to series 7, vol. xx. Lois, Décrets, etc., complete from series 6, vol. i., to series 7, vol. x. Personnel, complete from 1881 to 1900.
*Annales des Travaux Publics de Belgique, Brussels. Complete, except vols. vii. and viii.
Anthracite Coal Operators' Association, New York City. Complete from August, 1897, to April, 1902.
‡Arms and Explosives, London. Complete from vol. i., 1892.
‡Armstrong College, Newcastle-upon-Tyne. Calendar, complete from 1872, except 1881-1882.
Association de la Presse Technique, Brussels. Index, complete from vol. i., 1903, to vol. iii., 1904.
*Association des Ingénieurs sortis de l'École de Liége, Liége. Annuaire, complete. Bulletin, complete.
‡Association of Civil Engineers of Cornell University, Ithaca. Transactions, complete from vol. x., 1902.
‡Association of Engineering Societies, Philadelphia. Journal, complete from vol. i., 1882, except vols. i., nos. 1 to 5, and vol. vii., no. 3 (out of print).
‡Association of Water Engineers, London. Transactions, complete from vol. i., 1896.
*Atti della Società Toscana di Scienze Naturali, Pisa. Memorie, complete from 1877. Processi Verbali, complete, except vol. vii., pages 171-198 (out of print).
*Australasian Association for the Advancement of Science, Sydney, New South Wales. Reports, complete.
†Australasian Institute of Mining Engineers, Melbourne. Transactions, complete from vol. i.
‡Australian Mining Standard, Melbourne. Vol. vii., 1892, no. 187: vol. x., 1894, no. 275; and complete from vol. xi., no. 355.
‡Australian Official Journal of Patents, Melbourne. Complete from vol. iv., 1906.
‡Australian Official Journal of Trade Marks, Melbourne. Complete from vol. i., 1906.
‡Automotor Journal, London. Complete from vol. vi., 1901.

Barometer Readings, taken in the Wood Memorial Hall of The North of England Institute of Mining and Mechanical Engineers, Newcastle-upon-Tyne. Complete from 1873.

*Barrow Naturalists' Field Club, Barrow-in-Furness. Annual Reports, Proceedings, etc., complete from vol. i., 1877.
Berg- und Huettenmännische Zeitung, Leipzig. Complete from vol. xlii., 1883, to vol. lxiii., 1904.
Berg- und Hüttenmännisches Jahrbuch der Bergakademien zu Leoben und Přibram und der Königlich-ungarischen Bergakademie zu Schemnitz, Vienna. Complete from vol. xxxi., 1883.
‡Bibliographie des Sciences et de l'Industrie, Paris. Complete from commencement, 1898.
*Birmingham Natural History and Philosophical Society, Birmingham. Proceedings, complete from vol. i., 1876.
‡Birmingham University Mining Society, Birmingham. Quarterly Journal, complete from vol. i., 1905.
‡Board of Trade Journal, London. Complete from 1886.
‡Boletin Minero y Comercial, Madrid. Complete from 1898.
Boring and Drilling, London. Complete.
‡Brazilian Mining Review, Rio de Janeiro. Complete from vol. i., 1902.
‡British Association for the Advancement of Science, London. Complete from 1831.
‡British Columbia. Annual Report of the Minister of Mines, Victoria. Complete from 1898.
‡British Columbia. Bureau of Provincial Information, Victoria. Bulletin, nos. 1, 9, 10, 11, 15 and 19.
‡British Columbia Mining Exchange and Investors' Guide, Vancouver. Complete from vol. i., 1899, no. 12.
‡British Columbia Mining Record, Victoria. Complete from vol. v., 1899.
‡British Engine, Boiler and Electrical Insurance Company, Limited, Manchester. Chief Engineer's Reports, complete from 1880.
‡British Guiana. Department of Mines, Georgetown, Demerara. Report of the Commissioner of Mines for the year 1893-94. Reports of the Department of Lands and Mines for the years 1901-1902, 1902-1903, 1903-1904, 1904-1905 and 1905-1906. Fourteenth Annual Report of the Institute of Mines and Forests, 1902-1903. General Information with regard to the Gold, Diamond and Forest Industries, 1903. The Mining Ordinance, No. 1 of 1903; and Mining Regulations, 1903.
British Refrigeration and Allied Interests, London. Complete from vol. i., 1899, to vol. vii., 1904, no. 61, except vol. iii., no. 19.
‡British Society of Mining Students, Manchester. Journal, complete from vol. i., 1876.
‡British South Africa Company, London. Directors' Report and Accounts, complete from 1897-1898. Information as to Mining in Rhodesia, complete. Reports on the Administration of Rhodesia, complete from 1897-1898.
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The Library comprises over 10,000 Volumes, etc., treating of Geology, and Mining, Mechanical, and Civil Engineering.

August 3rd, 1907.

CHARTER OF THE NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

FOUNDED 1852.

INCORPORATED NOVEMBER 28TH, 1876.

Victoria, by the Grace of God, of the United Kingdom of Great Britain and Ireland, Queen, Defender of the Faith, TO ALL TO WHOM THESE PRESENTS SHALL COME, GREETING :

WHEREAS it has been represented to us that NICHOLAS WOOD, of Hetton, in the County of Durham, Esquire (since deceased) ; THOMAS EMERSON FORSTER, of Newcastle-upon-Tyne, Esquire (since deceased) ; SIR GEORGE ELLIOT, Baronet (then George Elliot, Esquire), of Houghton Hall, in the said County of Durham, and EDWARD FENWICK BOYD, of Moor House, in the said County of Durham, Esquire, and others of our loving subjects, did, in the year one thousand eight hundred and fifty-two, form themselves into a Society, which is known by the name of THE NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS, having for its objects the Prevention of Accidents in Mines and the Advancement of the Sciences of Mining and Engineering generally, of which Society LINDSAY WOOD, of Southill, Chester-le-Street, in the County of Durham, Esquire, is the present President. AND WHEREAS it has been further represented to us that the Society was not constituted for gain, and that neither its projectors nor Members derive nor have derived pecuniary profit from its prosperity ; that it has during its existence of a period of nearly a quarter of a century steadily devoted itself to the preservation of human life and the safer development of mineral property ; that it has contributed substantially and beneficially to the prosperity of the country and the welfare and happiness of the working members of the community ; that the Society has since its establishment diligently pursued its aforesaid objects, and in so doing has made costly experiments and researches with a view to the saving of life by improvements in the ventilation of mines, by ascertaining the conditions under which the safety lamp may be relied on for security ; that the experiments conducted by the Society have related to accidents in mines of every description, and have not been limited to those proceeding from explosions ; that the various modes of getting coal, whether by mechanical appliances or otherwise, have received careful and continuous attention, while the improvements in the mode of working and hauling belowground, the machinery employed for preventing the disastrous falls of roof underground, and the prevention of spontaneous combustion in seams of coal as well as in cargoes, and the providing additional security for the miners in ascending and descending the pits, the improvements in the cages used for this purpose, and in the safeguards against what is technically known as "overwinding," have been most successful in lessening the dangers of mining, and in preserving human life ; that the Society has held meetings at stated

periods, at which the results of the said experiments and researches have been considered and discussed, and has published a series of Transactions, filling many volumes, and forming in itself a highly valuable Library of scientific reference, by which the same have been made known to the public, and has formed a Library of Scientific Works and Collections of Models and Apparatus, and that distinguished persons in foreign countries have availed themselves of the facilities afforded by the Society for communicating important scientific and practical discoveries, and thus a useful interchange of valuable information has been effected; that in particular, with regard to ventilation, the experiments and researches of the Society, which have involved much pecuniary outlay and personal labour, and the details of which are recorded in the successive volumes of the Society's Transactions, have led to large and important advances in the practical knowledge of that subject, and that the Society's researches have tended largely to increase the security of life; that the Members of the Society exceed 800 in number, and include a large proportion of the leading Mining Engineers in the United Kingdom. And whereas in order to secure the property of the Society, and to extend its useful operations, and to give it a more permanent establishment among the Scientific Institutions of our Kingdom, we have been besought to grant to the said Lindsay Wood, and other the present Members of the Society, and to those who shall hereafter become Members thereof, our Royal Charter of Incorporation. Now know ye that we, being desirous of encouraging a design so laudable and salutary, of our especial grace, certain knowledge, and mere motion, have willed, granted, and declared, and do, by these presents, for us, our heirs, and successors, will, grant, and declare, that the said Lindsay Wood, and such others of our loving subjects as are now Members of the said Society, and such others as shall from time to time hereafter become Members thereof, according to such Bye-laws as shall be made as hereinafter mentioned, and their successors, shall for ever hereafter be, by virtue of these presents, one body, politic and corporate, by the name of "The North of England Institute of Mining and Mechanical Engineers," and by the name aforesaid shall have perpetual succession and a Common Seal, with full power and authority to alter, vary, break, and renew the same at their discretion, and by the same name to sue and be sued, implead and be impleaded, answer and be answered unto, in every Court of us, our heirs and successors, and be for ever able and capable in the law to purchase, acquire, receive, possess, hold, and enjoy to them and their successors any goods and chattels whatsoever, and also be able and capable in the law (notwithstanding the statutes of mortmain) to purchase, acquire, possess, hold and enjoy to them and their successors a hall or house, and any such other lands, tenements, or hereditaments whatsoever, as they may deem requisite for the purposes of the Society, the yearly value of which, including the site of the said hall or house, shall not exceed in the whole the sum of three thousand pounds, computing the same respectively at the rack rent which might have been had or gotten for the same respectively at the time of the purchase or acquisition thereof. And we do hereby grant our especial license and authority unto all and every person and persons and bodies politic and corporate, otherwise competent, to grant, sell, alien, convey or devise in mortmain unto and to the use of the said Society and their successors, any lands, tenements, or hereditaments not exceeding

with the lands, tenements or hereditaments so purchased or previously acquired, such annual value as aforesaid, and also any moneys, stocks, securities, and other personal estate to be laid out and disposed of in the purchase of any lands, tenements or hereditaments not exceeding the like annual value. And we further will, grant, and declare, that the said Society shall have full power and authority, from time to time, to sell, grant, demise, exchange and dispose of absolutely, or by way of mortgage, or otherwise, any of the lands, tenements, hereditaments and possessions, wherein they have any estate or interest, or which they shall acquire as aforesaid, but that no sale, mortgage, or other disposition of any lands, tenements, or hereditaments of the Society shall be made, except with the approbation and concurrence of a General Meeting. And our will and pleasure is, and we further grant and declare that for the better rule and government of the Society, and the direction and management of the concerns thereof, there shall be a Council of the Society, to be appointed from among the Members thereof, and to include the President and the Vice-Presidents, and such other office-bearers or past office-bearers as may be directed by such Bye-laws as hereinafter mentioned, but so that the Council, including all *ex-officio* Members thereof, shall consist of not more than forty or less than twelve Members, and that the Vice-Presidents shall be not more than six or less than two in number. And we do hereby further will and declare that the said Lindsay Wood shall be the first President of the Society, and the persons now being the Vice-Presidents, and the Treasurer and Secretary, shall be the first Vice-Presidents, and the first Treasurer and Secretary, and the persons now being the Members of the Council shall be the first Members of the Council of the Society, and that they respectively shall continue such until the first election shall be made at a General Meeting in pursuance of these presents. And we do hereby further will and declare that, subject to the powers by these presents vested in the General Meetings of the Society, the Council shall have the management of the Society, and of the income and property thereof, including the appointment of officers and servants, the definition of their duties, and the removal of any of such officers and servants, and generally may do all such acts and deeds as they shall deem necessary or fitting to be done, in order to carry into full operation and effect the objects and purposes of the Society, but so always that the same be not inconsistent with, or repugnant to, any of the provisions of this our Charter, or the Laws of our Realm, or any Bye-law of the Society in force for the time being. And we do further will and declare that at any General Meeting of the Society, it shall be lawful for the Society, subject as hereinafter mentioned, to make such Bye-laws as to them shall seem necessary or proper for the regulation and good government of the Society, and of the Members and affairs thereof, and generally for carrying the objects of the Society into full and complete effect, and particularly (and without its being intended hereby to prejudice the foregoing generality), to make Bye-laws for all or any of the purposes hereinafter mentioned, that is to say: for fixing the number of Vice-Presidents, and the number of Members of which the Council shall consist, and the manner of electing the President and Vice-Presidents, and other Members of the Council, and the period of their continuance in office, and the manner and time of supplying any vacancy therein; and for regulating the times at which General Meetings of the Society and Meetings of the Council shall be held,

and for convening the same and regulating the proceedings thereat, and for regulating the manner of admitting persons to be Members of the Society, and of removing or expelling Members from the Society, and for imposing reasonable fines or penalties for non-performance of any such Bye-laws, or for disobedience thereto, and from time to time to annul, alter, or change any such Bye-laws, so always that all Bye-laws to be made as aforesaid be not repugnant to these presents, or to any of the laws of our Realm. AND WE DO FURTHER will and declare that the present Rules and Regulations of the Society, so far as they are not inconsistent with these presents, shall continue in force, and be deemed the Bye-laws of the Society until the same shall be altered by a General Meeting, PROVIDED ALWAYS that the present Rules and Regulations of the Society and any future Bye-laws of the Society so to be made as aforesaid shall have no force or effect whatsoever until the same shall have been approved in writing by our Secretary of State for the Home Department. IN WITNESS WHEREOF WE HAVE CAUSED THESE OUR LETTERS TO BE MADE PATENT.

Witness Ourself at our Palace, at Westminster, the 28th day of November, in the fortieth year of our reign.

By Her Majesty's Command.

CARDEW.

Great Seal of the United Kingdom.

BYE-LAWS.

I.—CONSTITUTION.

1.—The North of England Institute of Mining and Mechanical Engineers shall consist of Members, Associate Members and Honorary Members. The Institute shall in addition comprise Associates and Students.

2.—The Officers of the Institute, other than the Treasurer and the Secretary, shall be elected from the Members and Associate Members, and shall consist of a President, six Vice-Presidents, and eighteen Councillors, who, with the Treasurer and the Secretary (if Members of the Institute) shall constitute the Council.

All Past-Presidents shall be *ex-officio* Members of the Council, so long as they continue Members or Associate Members of the Institute; and Vice-Presidents who have not been re-elected or have become ineligible from having held office for three consecutive years, shall be *ex-officio* Members of the Council for the following year.

II.—QUALIFICATIONS OF MEMBERS, ASSOCIATE MEMBERS, HONORARY MEMBERS, ASSOCIATES AND STUDENTS.

3.—MEMBERS.—Every candidate for admission into the class of Members, or for transfer into that class, shall come within the following conditions:—He shall be more than twenty-three years of age, have been regularly educated as a Mining or Mechanical Engineer, or in some other

branch of Engineering, according to the usual routine of pupilage, and have had subsequent employment for at least two years in some responsible situation as an Engineer, or if he has not undergone the usual routine of pupilage, he must have been employed or have practised as an Engineer for at least five years. This class shall also comprise every person who was an Ordinary Member, Life Member, or Student on the first of August, 1877.

4.—Associate Members shall be persons connected with or interested in Mining or Engineering, and not practising as Mining or Mechanical Engineers, or in some other branch of Engineering.

5.—Honorary Members shall be persons who have distinguished themselves by their literary or scientific attainments, or who have made important communications to the Society.

6.—Associates shall be persons acting as under-viewers, under-managers, or in other subordinate positions in mines, or employed in analogous positions in other branches of Engineering.

7.—Students shall be persons who are qualifying themselves for the profession of Mining or Mechanical Engineering, or other branch of Engineering, and such persons may continue Students until they attain the age of twenty-five years.

III.—Election and Expulsion of Members.

8.—Any person desirous of becoming a Member, an Associate Member, an Associate or a Student, shall be proposed according to the proper Form in the Appendix, in which Form the name, usual residence, and qualifications of the candidate shall be distinctly specified. The Form must be signed by the proposer and at least two other Members or Associate Members, certifying a personal knowledge of the candidate, who shall himself sign the undertaking contained therein.

Any person qualified to become an Honorary Member shall be proposed according to the proper Form in the Appendix, in which Form the name, usual residence, and qualifications of the candidate shall be distinctly stated. This Form must be signed by the proposer and at least five other Members or Associate Members, certifying a personal knowledge of the candidate, who shall himself sign the undertaking contained therein, and the Council shall have the power of defining the time during which, and the circumstances under which the candidate shall be an Honorary Member.

Any Associate or Student desirous of becoming a Member, shall be proposed and recommended according to the proper Form in the Appendix, in which Form the name, usual residence, and qualifications of the candidate shall be distinctly specified. This Form must be signed by the proposer and at least two other Members or Associate Members, certifying a personal knowledge of the candidate, who shall himself sign the undertaking contained therein, and the proposal shall then be treated in the manner hereinafter described.

Every proposal shall be delivered to the Secretary, and by him submitted to the next meeting of the Council, who, on approving the qualifications, shall determine if the candidate is to be presented for ballot, and if it is so determined, the Chairman of the Council shall sign such proposal. The same shall be read at the next Ordinary General Meeting, and afterwards be exhibited in the Institute's Hall until the following Ordinary General Meeting, when the candidate shall be balloted for.

A Student may become an Associate at any time after attaining the age of twenty-one years.

9.—The balloting shall be conducted in the following manner:—Each Member or Associate Member attending the meeting, at which a ballot is to take place, shall be supplied (on demand) with a list of the names of the persons to be balloted for, according to the proper Form in the Appendix, and shall strike out the names of such candidates as he desires shall not be elected, and return the list to the scrutineers appointed by the presiding Chairman for the purpose, and such scrutineers shall examine the lists so returned, and inform the meeting what elections have been made. No candidate shall be elected unless he secures the votes of two-thirds of the Members and Associate Members voting.

10.—Notice of election shall be sent to every person within one week after his election, according to the proper Form in the Appendix, and the person elected shall send the amount of his annual subscription, or life composition, within four months from the date of such election, which otherwise shall become void.

11.—Every Member having signed a declaration according to the proper Form in the Appendix, and having likewise made the proper payment, shall receive a certificate of his election, according to the proper Form in the Appendix.

12.—Any Member, Associate Member, Associate or Student elected at any meeting between the Annual Meetings shall be entitled to all Transactions issued in the Institute's year, so soon as he has signed and returned a declaration according to the proper Form in the Appendix, and paid his subscripton.

13.—The Transactions of the Institute shall not be forwarded to those whose subscriptions are in arrear on the first of November in each year.

14.—Any person whose subscription is more than one year in arrear shall be reported to the Council, who shall direct application to be made for it, according to the proper Form in the Appendix, and in the event of its continuing one month in arrear after such application, the Council shall have the power, after remonstrance by letter to his last recorded address in the books of the Society, according to the proper Form in the Appendix, of declaring that the defaulter has ceased to be a Member.

15.—In case the expulsion of any person shall be judged expedient by ten or more Members or Associate Members, and they think fit to draw up and sign a proposal requiring such expulsion, the same being delivered to the Secretary, shall be by him laid before the next meeting of the Council for consideration. If the Council, after due inquiry, do not find reason to concur in the proposal, no entry thereof shall be made in any minutes, nor shall any public discussion thereon be permitted, unless by requisition signed by one-half of the Members or Associate Members of the Institute; but if the Council do find good reason for the proposed expulsion, they shall direct the Secretary to address a letter, according to the proper Form in the Appendix, to the person proposed to be expelled, advising him to withdraw from the Institute. If that advice be followed, no entry on the minutes nor any public discussion on the subject shall be permitted; but if that advice be not followed, nor an explanation given which is satisfactory to the Council, they shall call a General Meeting for the purpose of deciding on the question of expulsion; and if a majority of the Members and Associate Members present at such meeting (provided

the number so present be not less than forty) vote that such person be expelled, the Chairman of that meeting shall declare the same accordingly, and the Secretary shall communicate the same to the person, according to the proper Form in the Appendix.

IV.—Subscriptions.

16.—The annual subscription of each Member and Associate Member shall be £2 2s., of each Associate and Student £1 5s., payable in advance, and shall be considered due on election, and afterwards on the first Saturday in August of each year.

17.—Any Member, Associate Member, Associate or Student, may, at any time, compound for all future subscriptions by a payment in accordance with the following scale:—

Under 30	years of age,	the sum of	£31
Over 30	,,	,,	,,	27
,, 40	,,	,,	,,	24
,, 50	,,	,,	,,	21
,, 60	,,	,,	,,	17

or on such other conditions as the Council may, in writing, accept. Every person so compounding shall be a Member, Associate Member, Associate or Student for life, as the case may be. Any Associate Member, Associate or Student so compounding who may afterwards be qualified to become a Member, may do so, by election in the manner described in Bye-law 8. All compositions shall be deemed capital money of the Institute.

18.—In case any Member, Associate Member or Associate, who has been long distinguished in his professional career, becomes unable, from ill-health, advanced age, or other sufficient cause, to carry on a lucrative practice, the Council may, on the report of a Sub-Committee appointed by them for that purpose, if they find good reason for the remission of the annual subscription, so remit it. They may also remit any arrears which are due from a Member, or they may accept from him a collection of books, or drawings, or models, or other contributions, in lieu of the composition mentioned in Bye-law 17, and may thereupon release him from any or all future subscriptions, and permit him to resume his former rank in the Institute.

19.—Owners of Collieries, Engineers, Manufacturers, Railway Companies, and Employers of labour generally, may subscribe annually to the funds of the Institute, and each such subscriber of £2 2s. annually shall be entitled to tickets to admit two persons to the rooms, library, meetings, lectures, and public proceedings of the Society; and for every additional £2 2s., subscribed annually, two other persons shall be admissible; and each such subscriber shall also be entitled for each £2 2s. subscription to have a copy of the Transactions of the Institute sent to him.

V.—Election of Officers.

20.—The President, Vice-Presidents, and Councillors shall be elected at the Annual Meeting in August (except in cases of vacancies) and shall be eligible for re-election to any office, with the exception of any President who may have held office for the two immediately preceding years, or Vice-President who may have held office for the three immediately preceding years, and such six Councillors as may have attended the fewest

Council Meetings during the past year, and when any such attendances are equal, the Council shall decide between them ; but any such Member or Associate Member shall be eligible for re-election after being one year out of office.

Any Retiring Vice-President or Councillor who may be ineligible for re-election shall nevertheless be eligible to any other office.

21.—Each Member and Associate Member shall be at liberty to nominate in writing, and send to the Secretary not less than eight days prior to the Ordinary General Meeting in June, a list, duly signed, of Members and Associate Members suitable to fill the offices of President, Vice-Presidents, and Members of Council for the ensuing year. The Council shall prepare a list of the persons so nominated, together with the names of the Officers for the current year eligible for re-election, and of such other Members and Associate Members as they deem suitable for the various offices. Such lists shall comprise the names of not less than thirty persons. The list so prepared by the Council shall be submitted to the Ordinary General Meeting in June, and shall be the balloting list for the annual election in August. (See proper Form in the Appendix.) A copy of this list shall be posted at least seven days previous to the Annual Meeting to every Member and Associate Member, who may erase any name or names from the list, and substitute the name or names of any other Member or Associate Member eligible for each respective office ; but the number of names on the list, after such erasure or substitution, must not exceed the number to be elected to the respective offices. Papers which do not accord with these directions shall be rejected by the scrutineers. The votes for any Member who may not be elected President or Vice-Presidents shall count for them as Members of the Council, but in no case shall he receive more than one vote from each voter. The Chairman shall appoint four scrutineers, who shall receive the balloting papers, and, after making the necessary scrutiny, destroy the same, and sign and hand to the Chairman a list of the elected Officers. The balloting papers may be returned through the post, addressed to the Secretary, or be handed to him, or to the Chairman of the meeting, so as to be received before the appointment of the scrutineers for the election of Officers.

22.—In case of the decease, expulsion, or resignation of any Officer or Officers, the Council, if they deem it requisite that the vacancy shall be filled up, shall present to the next Ordinary General Meeting a List of persons whom they nominate as suitable for the vacant office or offices, and a new Officer or Officers shall be elected at the first succeeding Ordinary General Meeting.

23.—The Treasurer and the Secretary shall be appointed by the Council, and shall be removable by the Council, subject to appeal to a General Meeting. One and the same person may hold both these offices.

VI.—Duties of the Officers and Council.

24.—The President shall take the chair at all meetings of the Institute, the Council, and Committees, at which he is present (he being *ex-officio* a member of all), and shall regulate and keep order in the proceedings.

25.—In the absence of the President, it shall be the duty of the senior Vice-President present to preside at the meetings of the Institute, to keep order, and to regulate the proceedings. In case of the absence of

the President and of all the Vice-Presidents, the meeting may elect any Member of Council, or in case of their absence, any Member or Associate Member present, to take the chair at the Meeting.

26.—At Meetings of the Council, five shall be a quorum. The minutes of the Council's proceedings shall be at all times open to the inspection of the Members and Associate Members.

27. The Treasurer and the Secretary shall act under the direction and control of the Council, by which body their duties shall from time to time be defined.

28.—The Council may appoint Committees for the purpose of transacting any particular business, or of investigating any specific subject connected with the objects of the Institute. Such Committees shall make a report to the Council, who shall act thereon, and make use thereof as they see occasion.

VII.—Communications and Memoirs.

29.—All papers shall be sent for the approval of the Council at least twenty-one days before a General Meeting, and after approval, shall be read before the Institute. The Council shall also direct whether any paper read before the Institute shall be printed in the Transactions, and immediate notice shall be given to the writer whether it is to be printed or not.

30.—The copyright of all papers communicated to, and accepted for printing by the Council, and printed within twelve months, shall become vested in the Institute, and such communications shall not be published for sale or otherwise, without the written permission of the Council.

31.—Twenty copies of each paper printed by the Institute shall be presented to the author for private use.

32.—All proofs of reports of discussions, forwarded to any person for correction, must be returned to the Secretary within seven days from the date of their receipt, otherwise they will be considered correct and be printed off.

33.—The Institute is not, as a body, responsible for the statements and opinions advanced in the papers which may be read, nor in the discussions which may take place at the meetings of the Institute.

VIII.—Meetings of the Institute.

34.—An Ordinary General Meeting shall be held on the first Saturday of every month (except January and July) at two o'clock, unless otherwise determined by the Council; and the Ordinary General Meeting in the month of August shall be the Annual Meeting, at which a report of the proceedings, and an abstract of the accounts of the previous year, shall be presented by the Council.

35.—All donations to the Institute shall be acknowledged in the Annual Report of the Council.

36.—A Special General Meeting shall be called whenever the Council may think fit, and also on a requisition to the Council, signed by ten or more Members or Associate Members. The business of a Special Meeting shall be confined to that specified in the notice convening it.

37.—The Members, Associate Members, Honorary Members, Associates and Students, shall have notice of, and the privilege to attend, all Ordinary General Meetings and Special Meetings.

38.—Every question, not otherwise provided for, which shall come before any meeting, shall be decided by the votes of the majority of the Members and Associate Members then present.

39.—Invitations shall be forwarded to any person whose presence at the discussions the Council may think advisable, and strangers so invited shall be permitted to take part in the proceedings but not to vote.

Any Member or Associate Member shall have power to introduce two strangers (see proper Form in the Appendix) to any General Meeting, but they shall not take part in the proceedings except by permission of the meeting.

IX.—Property of the Institute.

40.—The Funds of the Society shall be deposited in the hands of the Treasurer, and shall be disbursed or invested by him according to the direction of the Council.

41.—The Institute Hall and Reading Room shall be open to the Members, Associate Members, Honorary Members, Associates and Students on every week day, from 10 a.m. to 5 p.m., except on such special day or days when the Council shall think it expedient to close the rooms and suspend the circulation of Books. Books shall be issued according to regulations from time to time approved by the Council.

42.—No duplicate copies of any portion of the Transactions shall be issued to any Member, Associate Member, Associate or Student, unless by order from the Council.

X.—Alteration of Bye-laws.

43.—No alteration shall be made in the Bye-laws of the Institute, except at the Annual Meeting, or at a Special Meeting for that purpose, and the particulars of every such alteration shall be announced at a previous Ordinary Meeting, and inserted in its minutes, and shall be exhibited in the room of the Institute fourteen days previous to such Annual or Special Meeting, and such Meeting shall have power to adopt any modification of such proposed alteration of the Bye-laws.

I hereby approve the foregoing Bye-laws.

M. W. RIDLEY,

One of Her Majesty's Principal Secretaries of State.

Whitehall,
23rd September, 1898.

APPENDIX TO THE BYE-LAWS.

FORM A, Member or Honorary Member.

A. B. [Christian Name, Surname, Occupation, and Address in full], born on the.....day of.....18 , being desirous of belonging to The North of England Institute of Mining and Mechanical Engineers, I recommend him, from *personal knowledge*, as a person in every respect worthy of that distinction, because—

[*Here specify distinctly the qualifications of the Candidate, according to the spirit of Bye-laws 3 or 5.*]

On the above grounds, I propose him to the Council as a proper person to belong to the Institute.

Signed .....Member or Associate Member.

Dated this.....day of.....190 .

We, the undersigned, concur in the above recommendation, from *personal knowledge*, being convinced that A. B. is in every respect a proper person to belong to the Institute.

..... } Two Members or Associate Members, or by Five Members or Associate Members in the case of the nomination of an Honorary Member.
..... }

[*Undertaking to be signed by the Candidate.*]

I, the undersigned, do hereby promise that, in the event of my election, I will be governed by the Royal Charter and Bye-laws of the Institute for the time being, or as they may hereafter be altered, amended, or enlarged under the powers of the said Royal Charter; and that I will promote the objects of the Institute as far as may be in my power, and will not aid in any unauthorised publication of the proceedings, and will attend the meetings thereof as often as I conveniently can; provided that whenever I shall signify in writing to the Secretary that I am desirous of withdrawing my name therefrom, I shall (after the payment of any arrears which may be due by me at that period) cease to belong to the Institute.

Signed.....

Dated this.....day of.....190 .

[*To be filled up by the Council.*]

The Council, having considered the above recommendation, present A. B. to be balloted for as a.....Member of The North of England Institute of Mining and Mechanical Engineers.

Signed.....Chairman.

Nominated at the Ordinary General Meeting ...190 .
Passed by the Council .....190 .
Elected at the Ordinary General Meeting .....190 . Age.....years.

FORM B, Associate Member, Associate or Student.

A. B. [Christian Name, Surname, Occupation, and Address in full], born on the.....day of.....18 , being desirous of belonging to The North of England Institute of Mining and Mechanical Engineers, I recommend him, from *personal knowledge*, as a person in every respect worthy of that distinction, and propose him to the Council as a proper person to belong to the Institute.

Signed.....Member or Associate Member.

Dated this.....day of.....190 .

We, the undersigned, concur in the above recommendation, from *personal knowledge*, being convinced that A. B. is in every respect a proper person to belong to the Institute.

..... } Two Members or
..... } Associate Members.

[*Undertaking to be signed by the Candidate.*]

I, the undersigned, do hereby promise that, in the event of my election, I will be governed by the Royal Charter and Bye-laws of the Institute for the time being, or as they may hereafter be altered, amended, or enlarged under the powers of the said Royal Charter; and that I will promote the objects of the Institute as far as may be in my power, and will not aid in any unauthorised publication of the proceedings, and will attend the meetings thereof as often as I conveniently can; provided that whenever I shall signify in writing to the Secretary that I am desirous of withdrawing my name therefrom, I shall (after the payment of any arrears which may be due by me at that period) cease to belong to the Institute.

Signed.....

Dated this.....day of.....190 .

[*To be filled up by the Council.*]

The Council, having considered the above recommendation, present A. B. to be balloted for as a.....of The North of England Institute of Mining and Mechanical Engineers.

Signed.....Chairman.

Nominated at the Ordinary General Meeting ...190 .
Passed by the Council .....190 .
Elected at the Ordinary General Meeting .....190 . Age.....years.

FORM C, TRANSFER TO MEMBER OR ASSOCIATE MEMBER.

A. B. [Christian Name, Surname, Occupation, and Address in full], born on the.....day of.....18 , at present a..... of The North of England Institute of Mining and Mechanical Engineers, being desirous of becoming a.....Member of the said Institute, I recommend him, from *personal knowledge*, as a person in every respect worthy of that distinction, because—

[*Here specify distinctly the qualifications of the Candidate, according to the spirit of Bye-laws 3 and 4.*]

On the above grounds, I propose him to the Council as a proper person to be admitted a.....Member.

Signed..... .....Member or Associate Member.

Dated this... .....day of.....190 .

We, the undersigned, concur in the above recommendation, from *personal knowledge*, being convinced that A. B. is in every respect a proper person to be admitted a.....Member.

..... } Two Members
..... } or Associate Members.

[*Undertaking to be signed by the Candidate.*]

I, the undersigned, do hereby promise that, in the event of my election, I will be governed by the Royal Charter and Bye-laws of the Institute for the time being, or as they may hereafter be altered, amended, or enlarged under the powers of the said Royal Charter; and that I will promote the objects of the Institute as far as may be in my power, and will not aid in any unauthorised publication of the proceedings, and will attend the meetings thereof as often as I conveniently can; provided that whenever I shall signify in writing to the Secretary that I am desirous of withdrawing my name therefrom, I shall (after the payment of any arrears which may be due by me at that period) cease to belong to the Institute.

Signed.....

Dated this.....day of.....190 .

[*To be filled up by the Council.*]

The Council, having considered the above recommendation, present A. B. to be balloted for as a.....Member of The North of England Institute of Mining and Mechanical Engineers.

Signed.....Chairman.

Nominated at the Ordinary General Meeting ...190 .
Passed by the Council .....190 .
Elected at the Ordinary General Meeting .....190 . Age.....years.

FORM D.

List of the names of persons to be balloted for at the Ordinary General Meeting on.....the.....day of.....190 .

MEMBERS:—

.....

ASSOCIATE MEMBERS:—

.....

HONORARY MEMBERS:—

.....

ASSOCIATES:—

.....

STUDENTS:—

.....

Strike out the names of such persons as you desire should *not* be elected, and hand the list to the Chairman.

FORM E.

SIR,—I beg leave to inform you that on the.....day of..... you were elected a.....of The North of England Institute of Mining and Mechanical Engineers. In conformity with its Bye-laws your election cannot be confirmed until your first annual subscription be paid, the amount of which is £....., and, at your option, a life-composition in accordance with the following scale:—

Under 30 years of age	...	...	...	...	...	...	£31
Over 30	,,	,,	...	...	...	...	27
,, 40	,,	,,	...	...	...	...	24
,, 50	,,	,,	...	...	...	...	21
,, 60	,,	,,	...	...	...	...	17

If the subscription is not received within four months from the present date, the election will become void under Bye-law 10.

All annual subscriptions are due on the first Saturday in August of each year.

I am, sir, yours faithfully,

Dated.....190 . .....Secretary.

FORM F.

THE NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.
Founded 1852. Incorporated by Royal Charter, A.D. 1876.

These are to certify that A. B. [Christian Name, Surname, Occupation, and Address in full] was elected a Member of The North of England Institute of Mining and Mechanical Engineers, at an Ordinary General Meeting held on the.....day of..... .. ..190 .

Witness our hands and seal this.....day of.....190 .

(Seal)

.....President.

.....Secretary.

FORM G.

SIR,—I am directed by the Council of The North of England Institute of Mining and Mechanical Engineers to draw your attention to Bye-law 14, and to remind you that the sum of £.....of your annual subscriptions to the funds of the Institute remains unpaid, and that you are in consequence in arrear of subscription. I am also directed to request that you will cause the same to be paid without further delay, otherwise the Council will be under the necessity of exercising their discretion as to using the power vested in them by the Article above referred to.

I am, sir, yours faithfully,

.....Secretary.

Dated.....190 .

FORM H.

SIR,—I am directed by the Council of The North of England Institute of Mining and Mechanical Engineers to inform you that, in consequence of non-payment of your arrears of subscription, and in pursuance of Bye-law 14, the Council have determined that unless payment of the amount £..... is made previous to the.....day of.....next, they will proceed to declare that you have ceased to be a Member of the Institute.

But, notwithstanding this declaration, you will remain liable for payment of the arrears due from you.

I am, sir, yours faithfully,

....Secretary.

Dated.....190 .

FORM I.

SIR,—I am directed by the Council of The North of England Institute of Mining and Mechanical Engineers to inform you that, upon mature consideration of a proposal which has been laid before them relative to you, they feel it their duty to advise you to withdraw from the Institute, or otherwise they will be obliged to act in accordance with Bye-law 15.

I am, sir, yours faithfully,

.....Secretary.

Dated.....190 .

FORM J.

SIR,—It is my duty to inform you that, under a resolution passed at a Special General Meeting of The North of England Institute of Mining and Mechanical Engineers, held on the.....day of.....190 , according to the provisions of Bye-law 15, you have ceased to be a..... of the Institute.

I am, sir, yours faithfully,

.....Secretary.

Dated.....190 .

FORM K, BALLOTING LIST.

Ballot to take place at the Annual Meeting on.....190.....at Two o'clock, p.m.

The names of persons for whom the voter does *not* vote must be erased, and the names of other persons eligible for re-election may be inserted in their place, provided the number remaining on the list does not exceed the number of persons to be elected.

PRESIDENT—Not more than ONE NAME to be returned, or the vote will be lost.

_____ President for the current year eligible for re-election.*

_____ } New Nominations.*

VICE-PRESIDENTS—Not more than SIX NAMES to be returned, or the vote will be lost.

The Votes for any Member who may not be elected President or Vice-Presidents shall count for them as Members of the Council, but in no case shall he receive more than one vote from each voter.

_____ } Vice-Presidents for the current year eligible for re-election.

_____ } New Nominations.

COUNCIL—Not more than EIGHTEEN NAMES to be returned, or the vote will be lost.

_____ } Members of the Council for the current year eligible for re-election.

_____ } New Nominations.

Any list returned with a greater number of Names than ONE PRESIDENT, SIX VICE-PRESIDENTS, or EIGHTEEN COUNCILLORS, Will be rejected by the Scrutineers as informal, and the Votes will consequently be lost.

* To be inserted when necessary.

Ex-Officio Members of the Council for the ensuing year :—

_____ } Past-Presidents.
_____ }

_____ } Retiring Vice-Presidents.
_____ }

Bye-law 21.

Each Member and Associate Member shall be at liberty to nominate in writing, and send to the Secretary not less than eight days prior to the Ordinary General Meeting in June, a list, duly signed, of Members and Associate Members suitable to fill the offices of President, Vice-Presidents, and Members of Council for the ensuing year. The Council shall prepare a list of the persons so nominated, together with the names of the Officers for the current year eligible for re-election, and of such other Members and Associate Members as they deem suitable for the various offices. Such list shall comprise the names of not less than thirty persons. The list so prepared by the Council shall be submitted to the Ordinary General Meeting in June, and shall be the balloting list for the annual election in August. (See proper Form in the Appendix.) A copy of this list shall be posted at least seven days previous to the Annual Meeting to every Member and Associate Member, who may erase any name or names from the list, and substitute the name or names of any other Member or Associate Member eligible for each respective office; but the number of names on the list, after such erasure or substitution, must not exceed the number to be elected to the respective offices. Papers which do not accord with these directions shall be rejected by the scrutineers. The votes for any member who may not be elected President or Vice-Presidents shall count for them as Members of the Council, but in no case shall he receive more than one vote from each voter. The Chairman shall appoint four scrutineers, who shall receive the balloting papers, and, after making the necessary scrutiny, destroy the same, and sign and hand to the Chairman a list of the elected Officers. The balloting papers may be returned through the post, addressed to the Secretary, or be handed to him, or to the Chairman of the meeting, so as to be received before the appointment of the scrutineers for the election of Officers.

Names substituted for any of the above are to be written in the blank spaces opposite those they are intended to supersede.

The following Members are ineligible from causes specified in Bye-law 20 :—

As President .....

As Vice-Presidents .....

As Councillors .....

FORM L.

Admit .....

of * .....

to the Ordinary General Meeting on Saturday, the.....

(Signature of Member, Associate Member, Associate or Student).....

The Chair to be taken at Two o'clock p.m.

I undertake to abide by the Bye-laws of The North of England Institute of Mining and Mechanical Engineers, and not to aid in any unauthorised publication of the Proceedings.

(Signature of Visitor).....

Not transferable.

MINERS' EIGHT-HOURS DAY COMMITTEE.

EVIDENCE BY MR. J. H. MERIVALE ON BEHALF OF THE NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

The North of England Institute of Mining and Mechanical Engineers, of which I have the honour to be President, was founded in 1852, and has at the present time 1,349 members. It was founded for "the purpose of the prevention of accidents in mines and the advancement of the sciences of mining and engineering generally." With these objects in view, it has recently published a report upon coal-cutting machinery; and is at present engaged in an investigation of the phenomena connected with coal-dust explosions.

I propose to confine my evidence in the schedule of questions to No. 7 (machinery) and No. 19 (safety) as more peculiarly within the province of The North of England Institute of Mining and Mechanical Engineers.

Question No. 7 (Machinery).

It is possible that a shorter day, if slightly elastic, might lead to the introduction of more machinery; but this could only be done gradually. Meanwhile a very great deal of suffering, due to the shortage of coal, would be endured, certainly by the consumer, and probably by the coal-miner also. Moreover, the invention and introduction of labour-saving appliances is a vital necessity for the coal-trade of the North of England, without the additional stimulus of a shorter day.

An important point affecting coal-mining, which, so far as I know, does not affect any other industry, is that the physical conditions are worsening from year to year. The thicker seams are becoming exhausted, the coal has to be sought at greater depths, etc. This is well known; but it does not appear to be well known that, great as are the advantages obtained from modern mining machinery, the introduction of it has not kept pace with the increase in the difficulties of mining. As an illustration, I may point out that the production of coal, per hand employed, in Northumberland for the five years 1901-1905 was 7½ per cent. less than it was in the five years 1881-1885 (as per returns of H.M. inspectors of mines), and this in spite of the fact that 11 per cent. more days were worked in 1901-1905 than in 1881-1885. There is a similar falling-off in Durham; and, in spite of more machinery, it now takes, in the North of England coal-field, 120 hands to do the work—that is, to produce the same

number of tons of coal—that was done by 100 hands about twenty years ago. Moreover, the ratio of men to boys employed is greater, so that this labour is more costly per unit than formerly.

Without some change in our methods of working, either the cost of coal will go up very materially, or we shall shut down our pits and get it from some other country—China, for example. When the cheapness of labour in China is considered, in conjunction with the immense coal-resources of that country, the latter appears the more likely alternative.

I am of opinion, therefore, that, quite apart from the reduction of output consequent upon a shorter day, if our mining industry is to continue, new and improved machinery must be introduced into our mines to cope with the continually increasing physical difficulties.

Mining machinery is of two kinds, namely:—(1) That employed near the shaft, both aboveground and belowground, for winding, pumping, hauling, etc. (2) That employed near the face, for the cutting and conveying of the coal.

The first is already fairly satisfactory. A winding-engine, for example, can do the work of many hundreds of men, and at a cost so low that there is not much margin for economy. But as to the second: In a mine where the conditions are favourable for hand-labour no coal-cutter has yet been introduced that can compete successfully with manual labour, and I am of opinion that it will be very many years before one will be invented.

The seams, however, that are suitable for hand-labour are being worked out, and at many collieries in the North of England part of the output is already derived from seams that cannot be worked at a profit by hand, and at these collieries coal-cutting machines are being gradually introduced; as also coal-conveyors, where the conditions are suitable.

Coal-cutters and conveyors, however, do not lend themselves to a rigid shift of any fixed number of hours, and this I have illustrated in the two sketches appended hereto. Fig. 1 (plate i.) shows a normal day, in which everything goes right, and each class of labour gets through its allotted work in its allotted time. Fig. 2 (plate i.) shows a day when by some chance—perhaps a fault in the strata, some hard brasses in the undercut, or other unavoidable occurrence—the machine-men do not complete their cut in their shift. The only result of this at present is that they work overtime so as to finish the cut, but under a rigid length of shift the whole district would be laid idle.

The same thing applies to other classes of labour. If the conveyor-men do not get the conveyor shifted up, and may not work overtime in order to do so, the district will also be laid idle.

The general conclusion arrived at, in the report upon coal-cutting before mentioned, was that "thin seams [unsuited to hand-labour] can be worked [by means of coal-cutters] at a rate of production per man employed, which will approximate to that of the thicker seams under hand-labour."*

This, however, was under the conditions of a shift more or

* *Report of the Committee upon Mechanical Coal-cutting*, 1905, page 5.

less elastic. And, although I am hardly prepared to say that coal-cutters and other labour-saving appliances, like conveyors, cannot be used at all at the coal-face with a rigid length of shift, I can say that they cannot be used with the highest efficiency: or, as I shall shew presently, with the maximum of safety for the workmen.

Question No. 19 (Safety).

There are but two generally accepted systems of colliery organization below ground, namely: The North of England system of two shifts of hewers to one shift, a longer one, for datal hands: and that adopted in other parts of England, namely, one shift for both hewers and datal hands.

The North of England system has, in my opinion, this advantage, that the work can be, and is, specialized. The hewers hew and fill their coals only: whilst another class of men, the deputies, who are men of exceptional skill, are employed to set the timber. It is probable that the immunity from accidents experienced in the North of England, compared with other districts, is very largely, perhaps entirely, due to this specialization of the work.

The collieries in the North of England can only be carried on under the Coal-mines (Eight Hours) Bill: (1) Either by reducing the hours of the hewers in the same proportion as the hours of the boys and other datal hands will be reduced, that is to say: In Northumberland about 7¼ hours, and in Durham 7 hours (in both cases from bank to bank), to about 5½ hours, that is, an average of about 4½ hours actual work. (2) Or by abandoning the present system of organization altogether, with its specialization of labour, and consequent immunity from accidents.

I do not know how the mines in the North will be organized under the Bill: but, for the purpose of eliciting opinion upon this point, I offered, in September of last year, a prize of £10 10s. "for the best practicable method of working the Northumberland collieries, under the Eight Hours Bill, without increasing the hours of the hewers." The response was very gratifying. More than seventy replies were received, sixty-nine of which were for competition, and were considered by Mr. H. F. Bulman, the adjudicator. Twenty-three of these were selected for publication, and were published in the *Newcastle Daily Chronicle* last November. I append diagrams illustrative of some of the essays.*

After a perusal of these essays, I am confirmed in my opinion that the present double-shift system of the North of England, with its specialization of labour and consequent immunity from accident, will have to be abandoned, in the event of a rigid maximum of eight hours per day being enforced. Further, though the matter is foreign to my present purpose, no one of the essayists surmounts this difficulty, namely, that additional datal hands

* The diagrams have not been reproduced.

will be required under the Bill; and these can only be obtained from the ranks of the hewers, that is, by reducing the output, and by degrading these hewers, both as to their position and wages, and as to their hours of work.

Coal-cutters and Conveyors in Relation to Safety.

The more extended use of these will be conducive to the safety of the workmen. To quote the report upon coal-cutting before mentioned:—"*Straightness of Face.*—This is an important point affecting, as it does, the work of the machine and the control of the roof. Projecting slabs of coal in an uneven face are specially liable to fall on to the machine and cause delay. A straight cut causes the coal to break off and fall more easily, and in many cases means less blasting, while it also allows the roof to subside evenly with regular lines of break, if any occur. With a straight face, timbering can be carried out with greater regularity, and consequently with greater safety."*

Whilst with hand-hewing a straight face, so important for the safety of the workmen, is impossible; with a coal-cutter it is not only necessary for the efficient working of the machine, but it is easily maintained so long as the shift is somewhat elastic. But, if the length of shift were to be rigidly fixed, there would be great difficulty in keeping a straight face. Again, quoting the report: "Mechanical coal-cutting renders possible a rapid advance of the face, which greatly assists the control of bad roofs. The straight line of face admits of a more regular subsidence or break of the roof, and shot-firing, with its disturbing influences on the roof, is much reduced."†

The fixed length of shift will also render more difficult this rapid and, I would add, as quite as important, regular advance of the face. If the cutter-men do not complete their task in the allotted time, the face will have to stand twenty-four hours upon the timber, and though in some cases it may take no serious harm, in many it will become unsafe.

I am firmly convinced that there must be some elasticity in the length of the shift, if much benefit is to be derived from the increased use of mechanical coal-getting, both as regards the safety of the workmen and as regards reduced cost of production.

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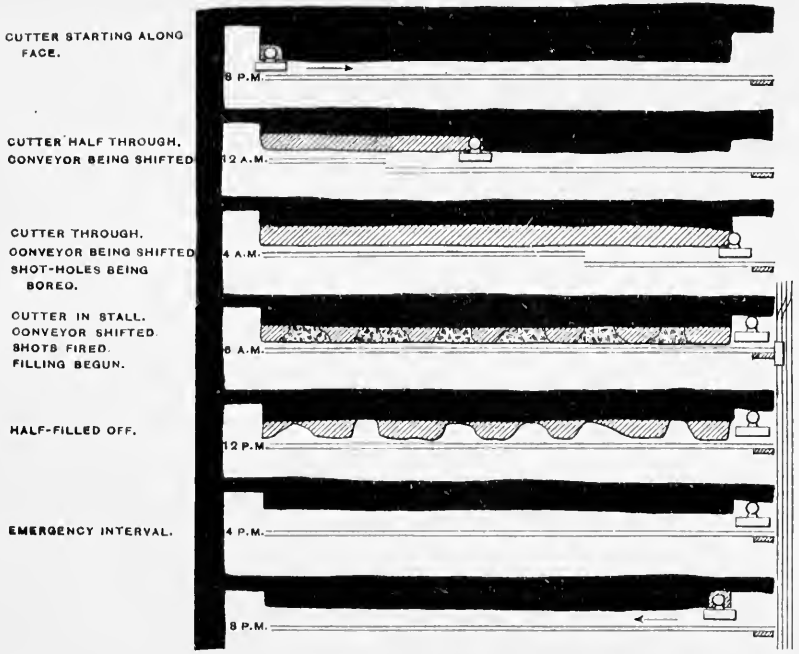
* *Report of the Committee upon Mechanical Coal-cutting*, 1905, page 8.

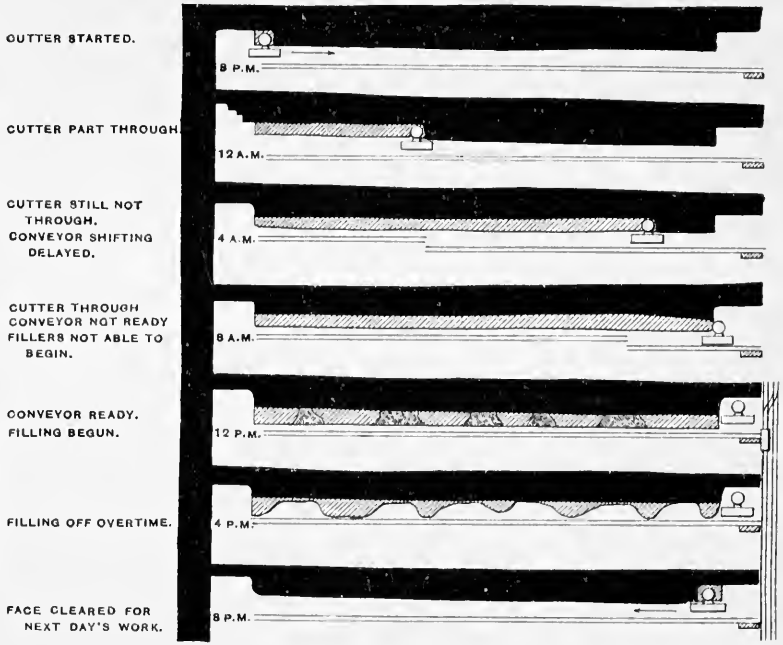
† *Ibid.*, page 11.

FIG. 1.—A NORMAL DAY'S WORK OF 24 HOURS, WITH ONE 8-HOURS' SHIFT OF MACHINE-MEN, FILLERS AND OTHER CLASSES OF LABOUR.



MACHINE-MEN .. .. .. 8 P.M. TO 4 A.M.
CONVEYOR-SHIFTERS AND SHOT FIRERS 12 ,, TO 4 ,,
FILLERS .. .. 8 A.M. TO 4 P.M.
THIS LEAVES AN INTERVAL OF 4 HOURS FOR EMERGENCIES.

FIG. 2.—A DAY DELAYED BY COAL-CUTTING DIFFICULTIES, SHOWING THAT WITH THE PRESENT SYSTEM OF AN ELASTIC SHIFT, THIS IS OF NO IMPORTANCE.



MACHINE-MEN, 8 P.M. TO 5 A.M., 1 HOUR OVERTIME.
CONVEYOR-SHIFTERS, 12 A.M., MAY OR MAY NOT BE DELAYED IN SHIFTING UP CONVEYOR.
FILLERS, DO. DO.

And.w Reid & Comp.y L.td Newcastle upon Tyne

MEMOIR.

George Henry Evans died at Berkeley, California, on February 4th, 1907. He was taken suddenly ill, and an operation on the gall-bladder resulted fatally. He was born at Hull, in England, forty-one years ago. He was a mining engineer in active and successful practice, his speciality being placer-mining. He was the inventor of the Evans hydraulic elevator, now used in hydraulic mines, where the elevation of gravel is necessary. He was a member of The North of England Institute of Mining and Mechanical Engineers, the American Institute of Mining Engineers, the American Society of Mechanical Engineers, the Technical Society of the Pacific Coast, and the Franklin Institute of the State of Pennsylvania. He leaves a widow, a son, and a daughter. He went to California, ten years ago, to take charge of the operations on the Golden Feather channel, at Oroville. Three years later, he became the manager of the Banner mine, also in Butte county. Subsequently he travelled widely, becoming consulting engineer of various alluvial enterprises in Colorado, California, and elsewhere. He was one of the consulting engineers associated with the Risdon iron-works, of San Francisco.

INDEX TO VOL. LVII.

Explanations.

The — at the beginning of a line denotes the repetition of a word; and in the case of Names, it includes both the Christian Name and the Surname; or, in the case of the name of any Firm, Association or Institution, the full name of such Firm, etc.

Discussions are printed in *italics*.

"Abs." signifies Abstracts of Foreign Papers at the end of the Proceedings.

"App." signifies Annual Report of the Council, etc., at the end of the Volume.

A.

Accounts, 12; app. iii., ix.
Accumulation of alluvial gold, cyperaceæ and, abs. 10.
Adamson, J., *liquid air and its use in rescue-apparatus*, 90.
Africa, Congo Free State, Katanga, copper, tin and gold, abs. 97.
Ahnert, E., gold-bearing regions of Siberia, abs. 90.
Ahnert, E., M. M. Ivanoff, A. Khlaponin, P. Rippas, and P. Yavorovsky, gold-bearing regions of Siberia, abs. 90.
Alluvial gold, accumulation, cyperaceæ and, abs. 10.
American Institute of Mining Engineers, visit to Newcastle-upon-Tyne, 1.
Ankylostomiasis, cutaneous infectivity, abs. 1.
Annual general meeting, 6.
— report of council, 7; app. iii., iii.
— — — finance committee, 10; app. iii., viii.
Archer, William, improved dampers for coke-oven flues.—Discussion, 37.
Argentiferous galena, Switzerland, Cadlimo, abs. 83.
Armstrong College, lectures for colliery engineers, etc., brief syllabus, app. iii., lvi.
Aschan, Ossian, humus and the formation of bog- and lake-ores, abs. 11.
Ashworth, James, *reports on circumstances attending explosion at Wingate Grange colliery*, 160.
Asia Minor, mineral resources, abs. 84.
Asphalt-deposit, Germany, Hesse, Mettenheim, abs. 51.
Asphaltic limestones, France, Gard, abs. 42.
Associate members, election, 18, 69, 123, 148, 174.
— —, list, app. iii., xliii.
Associates, election, 37, 69, 123, 148, 174.
—, list, app. iii., xlvii.
Atkinson, J. B., R. Donald Bain, and A. H. Ruegg, reports on circumstances attending explosion at Wingate Grange colliery.—Discussion, 151.
Auriferous deposits, Finnish Lapland, abs. 69.
— —, Servia, abs. 71.
— stibnite, France, Britanny, Martigné, abs. 39.
Austria-Hungary, Dalmatia, Ruda, tertiary coal-deposits, abs. 20.
— —, Galicia, Boryslaw, ozokerite-deposits, abs. 23.
— —, —, —, petroleum-deposits, abs. 23.
— —, Hungary, carboniferous marine strata, abs. 21.
— —, —, Kazanesd, pyritic deposits, abs. 24.
— —, —, Komarnik-Mikova and Luh, petroleum-bearing rocks, abs. 22.
— —, Tyrol, southern, copper-ores, abs. 25.
— —, —, —, wolfram-ores, abs. 25.
Automatic appliance for stopping and restarting mine-wagons, 19.
Axwell Park colliery, electric plant, 66.
Azurite-deposit, Italy, Sardinia, Castello di Bonvei, abs. 61.

B.

Bain, R. Donald, J. B. Atkinson, and A. H. Rueggg, reports on circumstances attending explosion at Wingate Grange colliery.—Discussion, 151.
Ballore, F. de Montessus de, seasonal distribution of earth-tremors, abs. 3.
Baratta, Mario, earthquake of 1905 in Calabria, Italy, abs. 5.
Barograph, Thwaite electro-, for mines, 29.
Barometer, thermometer, etc., readings, 1906, abs. 101.
Bathie, H. Perrier de la, and H. Jumelle, cyperaceæ and the accumulation of alluvial gold, abs. 10.
Beck, R., tungsten-ore deposits in Saxony, abs. 58.
Bedson, P. Phillips, *deposits in pit-fall at Tanfield Lea, Tantobie, County Durham*, 71.
Bedson, P. Phillips, and Henry Widdas, experiments illustrative of inflammability of mixtures of coal-dust and air, 73.—Discussion, 75.
Belgium, Campine coal-field, abs. 30.
—, Charleroi, coal-measures, marine band, abs. 28.
—, coal-measures, formation, abs. 26.
—, Hainaut, Baudour, coal-measures, lower, fauna, abs. 28.
—, —, —, — —, —, flora, abs. 29.
—, Liége, coal-measures, lower division, abs. 29.
—, Lienne, manganiferous iron-ores, abs. 33.
—, Mons, coal-measures, upper, marine bands, abs. 30.
Bell, Sir Lowthian, Bart., memoir, 187.
Benson, T. W., presentation of G. C. Greenwell medals, 17.
—, welcome to members of American Institute of Mining Engineers to Newcastle-upon-Tyne, 1.
Bergeron, Jules, coal-field of French Lorraine, abs. 36.
Bergeron, Jules, and Paul Weiss, coal-field of French Lorraine, abs. 35.
Berteaux, —, mineral resources of Korea, abs. 88.
Blackett, W. C., *appliance for automatically stopping and restarting mine-wagons*, 23.
—, awarded G. C. Greenwell medal, 17.
—, *experiments illustrative of inflammability of mixtures of coal-dust and air*, 75.
—, *new apparatus for rescue-work in mines*, 148, 149.
—, *reports on circumstances attending explosion at Wingate Grange colliery*, 156.
Blende-deposits, Norway, Traag, abs. 65.
Block, J., copper-ores and wolfram-ores in southern Tyrol, abs. 25.
Bog- and lake-ores, formation, humus, abs. 11.
Bog-ore, manganiferous, and formation of manganese-deposits, abs. 12.
Bore-holes, recent, Germany, Rhenish Prussia, Rhenish-Westphalian coal-field, abs. 47.
— —, —, —, Westphalia, Rhenish-Westphalian coal-field, abs. 47.
Borings for coal, unsuccessful, France, Picardy, abs. 37.
Bousquet, J. G., mining legislation in Holland, abs. 1.
Bowburn winning, 31.
Brace, James H., *sinking through magnesian limestone and yellow sand by freezing-process at Dawdon colliery, Seaham Harbour, County Durham*, 165.
Brough, Bennett H., *sinking through magnesian limestone and yellow sand by freezing-process at Dawdon colliery, Seaham Harbour, County Durham*, 122.
Brown, M. Walton, memoir of late John Daglish, 169.
—, *pneumatogen: self-generating rescue-apparatus, compared with other types*, 174.
—, *sinking through magnesian limestone and yellow sand by freezing-process at Dawdon colliery, Seaham Harbour, County Durham*, 176.
Brown-coal deposits, Germany, Silesia, Upper Lausitz, abs. 49.
Buttgenbach, H., copper, tin and gold in Katanga, Congo Free State, abs. 97, 98, 99.
Bye-laws, app. iii., lxxiii.

C.

Cpit, Monkwearmouth, 185.
Cambier, René, marine band in Charleroi coal-measures, Belgium, abs. 28.
Campine coal-field, Belgium, abs. 30.
Carboniferous marine strata in Hungary, abs. 21.
Carmaux-Albi coal-basins, France, abs. 34.
Carr, W. Ochran, *experiments illustrative of inflammability of mixtures of coal-dust and air*, 76.
Cayeux, L., iron-ore derived from glauconite, Ardennes, France, abs. 38,

Cayeux, L., magnetic iron-ore of Diélette, Lower Normandy, abs. 39.
Central America, Nicaragua, Masaya, earthquakes, 1906, abs. 9.
Charter, app. iii., lxx.
Chile, earthquake, 1906, abs. 7.
Coal, borings for, unsuccessful, France, Picardy, abs. 37.
Coal-basins, France, Carmaux-Albi, abs. 34.
Coal-bearing beds, Manchuria, southern, Fushun, abs. 88.
— — —, Russian Empire, Siberia, Kuznetsk district, abs. 89.
Coal-deposits, tertiary, Austria-Hungary, Dalmatia, Ruda, abs. 20.
Coal-dust and air, experiments illustrative of inflammability of mixtures of, 73.
— — in mines, aboveground and belowground, treatment, 178.
Coal-fields, Belgium, Campine, abs. 30.
— —, France, Lorraine, abs. 35.
— —, —, St. Etienne, shear-planes abs. 37.
— —, Germany, Rhenish Prussia, Aix-la-Chapelle, abs. 45.
— —, —, — —, Rhenish-Westphalian, recent bore-holes and sinkings, abs. 47.
— —, —, Silesia, Upper Lausitz, abs. 49.
— —, —, Westphalia, Rhenish-Westphalian, recent bore-holes and sinkings, abs. 47.
— —, Manchuria, southern, Fushun, abs. 88.
— —, Russian Empire, Siberia, Kuznetsk district, abs. 89.
Coal-measures, Belgium, Charleroi, marine band, abs. 28.
— —, —, formation, abs. 26.
— —, Germany, Silesia, Upper, *posidonia becheri* in, abs. 51.
— —, lower, Belgium, Hainaut, Baudour, fauna, abs. 28.
Coal-measures, lower, Belgium, Hainaut, Baudour, flora, abs. 29.
— —, —, —, Liége, abs. 29.
— —, upper, Belgium, Mons, marine bands, abs. 30.
Coke-oven flues, dampers, improved, 37.
Committees, 1907-1908, app. iii., xiv.
Concrete, ferro-, and its applications, 132.
Conveyors, sliding-trough, 166.
Copper, Africa, Congo Free State, Katanga, abs. 97.
Copper-ores, Austria-Hungary, Tyrol, southern, abs. 25.
Cornet, J., fauna of lower coal-measures of Baudour, Hainaut, abs. 28.
—, marine bands in upper coal-measures of Mons, Belgium, abs. 30.
Coulson, F., *experiments illustrative of inflammability of mixtures of coal-dust and air*, 76.
—, *sinking through magnesian limestone and yellow sand by freezing-process at Dawdon colliery, Seaham Harbour, County Durham*, 175, 177.
—, *treatment of dust in mines, aboveground and belowground*, 183.
Council, annual report, 7; app. iii., iii.
— of The Institution of Mining Engineers, election of representatives on, 11.
Cremer, R., *liquid air and its use in rescue-apparatus*, 83.
—, pneumatogen: self-generating rescue-apparatus, compared with other types.—Discussion, 174.
Crofton, C. A., *reports on circumstances attending explosion at Wingate Grange colliery*, 160.
—, *sliding-trough conveyors*, 168.
Cutaneous infectivity of ankylostomiasis, abs. 1.
Cyperaceæ and the accumulation of alluvial gold, abs. 10.

D.

Daglish, John, death, 35.
—, memoir, 169.
—, portrait, *frontispiece*.
Dampers, improved, for coke-oven flues, 37.
Dawdon colliery, 2.
— —, sinking through magnesian limestone and yellow sand by freezing-process, 95, 165, 175.
Deaths, Sir Lowthian Bell, Bart., 187.
—, John Daglish, 35.
—, George Henry Evans, app. iii., lxxxix.
Deposits in pit-fall at Tanfield Lea, Tantobie, County Durham, 24, 70.
Dickinson, Joseph, *liquid air and its use in rescue-apparatus*, 85.
Diffusion-theory, origin of ore-deposits, abs. 15.
Distribution, seasonal, of earth-tremors, abs. 3.
Ditte, Alfred, origin and age of metalliferous ores, abs. 14.
Douglas, Thomas, *appliance for automatically stopping and restarting mine-wagons*, 22.
—, death of John Daglish, 35.
Dust, coal-, in mines, aboveground and belowground, treatment, 178.

E.

Earth-tremors, Greece, 1900-1903, abs. 4.
— —, seasonal distribution, abs. 3.
Earthquakes, Central America, Nicaragua, Masaya, 1906, abs. 9.
—, Chile, 1906, abs. 7.
—, Finland, 1902, abs. 6.
—, Italy, Calabria, 1905, abs. 5.
—, Nicaragua, Masaya, 1906, abs. 9.
—, South America, Chile, 1906, abs. 7.
Eginitis, D., earth-tremors in Greece during years 1900 to 1903, abs. 4.
Einecke, G., Holzappel metalliferous belt, Hesse-Nassau, abs. 56.
Election of members, 18, 36, 69, 123, 147, 173.
— — officers, 6.
— — representatives on council of The Institution of Mining Engineers, 11.
Electric plant, Axwell Park colliery, 66.
Electro-barograph, Thwaite, for mines, 29.
Ellis, Arthur, *liquid air and its use in rescue-apparatus*, 91.
Ellis, Sir Joseph Baxter, welcome to members of American Institute of Mining Engineers to Newcastle-upon-Tyne, 1.
Evans, George Henry, memoir, app. iii., lxxxix.
Excursion meetings, 1, 31, 66, 185.
Exhaust-steam-driven three-phase haulage plant, Rateau, 71.
Explosion, Wingate Grange colliery, 151.

F.

Fauna, coal-measures, lower, Belgium, Hainaut, Baudour, abs. 28.
Ferro-concrete and its applications, 132.
Finance committee, annual report, 10; app. iii., viii.
Finland, earthquake, 1902, abs. 6.
Finnish Lapland, auriferous deposits, abs. 69.
Fircks, Curt, auriferous deposits of Finnish Lapland, abs. 69.
Fircks, Baron F., ore-deposits of province of Almeria, Spain, abs. 77, 78.
Fischer, H., mercury ore-deposits of Avala hill, Servia, abs. 73.
Flora, coal-measures, lower, Belgium, Hainaut, Baudour, abs. 29.
Flues, coke-oven, dampers, improved, 37.
Ford, M., *experiments illustrative of inflammability of mixtures of coal-dust and air*, 76.
Forir, H., A. Habets, and M. Lohest, Campine coal-field, Belgium, abs. 30.
Forster, T. E., *experiments illustrative of inflammability of mixtures of coal-dust and air*, 76.
—, *liquid air and its use in rescue-apparatus*, 127.
—, *new apparatus for rescue-work in mines*, 150.
—, *practical problems of machine-mining*, 39.
—, *reports on circumstances attending explosion at Wingate Grange colliery*, 158.
—, *sinking through magnesian limestone and yellow sand by freezing-process at Dawdon colliery, Seaham Harbour, County Durham*, 121.
Forster, T. E., *sliding-trough conveyors*, 168.
—, *valuation of mineral properties*, 63.
Fourmarier, P., lower division of Liége coal-measures, Belgium, abs. 29.
France, Alsace, Val de Villé, metalliferous deposits, abs. 41.
—, Ardennes, iron-ore derived from glauconite, abs. 38.
—, Britanny, Martigné, auriferous stibnite, abs. 39.
—, Carmaux-Albi coal-basins, abs. 34.
—, Gard, asphaltic limestones, abs. 42.
—, Lorraine, coal-field, abs. 35.
—, —, gold, abs. 40.
—, —, silver, abs. 40.
—, Lower Normandy, Diélette, magnetic iron-ore, abs. 39.
—, Pas-de-Calais, underground temperatures, abs. 2.
—, phosphatic deposits, abs. 44.
—, Picardy, coal, borings for, unsuccessful, abs. 37.
—, St. Étienne coal-field, shear-planes, abs. 37.
Frech, Fritz, carboniferous marine strata in Hungary, abs. 21.
Freezing-process, sinking through magnesian limestone and yellow sand, Dawdon colliery, 95, 165, 175.
Freise, Fr., mineral resources of Asia Minor, abs. 84.
Friedel, G., and P. Termier, shear-planes in St. Étienne coal-field, France, abs. 37.
Futers, T. C., *liquid air and its use in rescue-apparatus*, 131.
—, *sliding-trough conveyors*, 168.
—, *treatment of dust in mines, above-ground and below-ground*, 182, 183.

G.

Galena, argentiferous, Switzerland, Cadlimo, abs. 83.
Galena-deposits, Norway, Traag, abs. 65.
Galloway, W., appliance for automatically stopping and restarting mine-wagons, 19.—Discussion, 22.
Garforth, W. E., new apparatus for rescue-work in mines.—Discussion, 148.
General meetings, 1, 6, 31, 35, 66, 69, 123, 147, 173, 185.
Genesis of pisolitic iron-ores, abs. 18.
Gerasimoff, A., and P. I. Preobrazhensky, gold-bearing regions of Siberia, abs. 90.
Germany, Baden, Black Forest, nickeliferous magnetic pyrites, abs. 53.
—, Bavaria, Fichtelgebirge, stanniferous deposits, abs. 55.
—, Hesse, Mettenheim, asphalt-deposit, abs. 51.
—, Hesse-Nassau, Holzappel metalliferous belt, abs. 56.
—, Rhenish Prussia, Aix-la-Chapelle coal-field, abs. 45.
—, — —, Rhenish-Westphalian coal-field, recent bore-holes and sinkings, abs. 47.
—, Saxony, Halle-an-der-Saale, kaolin-deposits, abs. 52.
—, —, tungsten-ore deposits, abs. 58.
—, —, western Erzgebirge, pyrites-deposits, abs. 56.
Germany, Silesia, Upper, coal-measures, *posidonia becheri* in, abs. 51.
—, —, — Lausitz, brown-coal deposits, abs. 49.
—, Westphalia, Rhenish-Westphalian coal-field, recent bore-holes and sinkings, abs. 47.
Glauconite, iron-ore derived from, France, Ardennes, abs. 38.
Gold, Africa, Congo Free State, Katanga, abs. 97.
—, alluvial, accumulation, cyperaceæ and, abs. 10.
—, France, Lorraine, abs. 40.
Gold-bearing regions, Russian Empire, Siberia, abs. 90.
Gosselet, J., unsuccessful borings for coal in Picardy, France, abs. 37.
Grahn, Hermann, *liquid air and its use in rescue-apparatus*, 86.
Granite, iron-ores in, magmatic segregation, abs. 17.
Graphite-deposits, Italy, Piedmontese Alps, abs. 59.
— —, Lapland, abs. 69.
Greece, earth-tremors, 1900-1903, abs. 4.
Greenwell, G. C., medal, presentation of, 17.
Grzybowski, J., petroleum- and ozokerite-deposits of Boryslaw, Galicia, abs. 23.
Gueritte, T. J., ferro-concrete and its applications, 132.

H.

Habershon, M. H., *liquid air and its use in rescue-apparatus*, 84.
Habets, A., H. Forir, and M. Lohest, Campine coal-field, Belgium, abs. 30.
Hall, Henry, *liquid air and its use in rescue-apparatus*, 90.
Hamilton, J. A., *liquid air and its use in rescue-apparatus*, 87.
Hare, S., *reports on circumstances attending explosion at Wingate Grange colliery*, 159.
Harle, Richard, treatment of dust in mines, aboveground and belowground, 178.—Discussion, 181.
Haulage plant, Ratean exhaust-steam-driven three-phase, 71.
Hedley, A. M., *improved dampers for coke-oven flues*, 37.
—, *reports on circumstances attending explosion at Wingate Grange colliery*, 163.
Hobart, H. M., *practical problems of machine-mining*, 37.
Hodgson, L. H., *pneumatogen: self-generating rescue-apparatus, compared with other types*, 175.
Holland, mining legislation, abs. 1.
Holzappel metalliferous belt, Germany, Hesse-Nassau, abs. 56.
Honorary members, election, 36.
— —, list, app. iii., xvi.
Horden colliery, 4.
Humus and formation of bog- and lake-ores, abs. 11.
Hunt, Capt. Robert W., thanks for welcome to members of American Institute of Mining Engineers to Newcastle-upon-Tyne, 2.

I.

Infectivity, cutaneous, of ankylostomiasis, abs. 1.
Inflammability of mixtures of coal-dust and air, experiments illustrative of, 73.
Institution of Mining Engineers, election of representatives on council of, 11.
Iron-ore deposits, formation and classification, abs. 16.

Iron-ore in granite, magmatic segregation, abs. 17.
Iron-ores, France, Ardennes, derived from glauconite, abs. 38.
——, magnetic, France, Lower Normandy, Diélette, abs. 39.
——, manganiferous, Belgium, Lienne, abs. 33.
——, pisolitic, genesis, abs. 18.
——, Sweden, northern, Gellivaara, abs. 68.
——, ——, ——, Kiirunavaara, abs. 66, 68.
Italy, Calabria, earthquake, 1905, abs. 5.
——, Piedmontese Alps, graphite-deposits, abs. 59.
——, Sardinia, Cagliari district, tungsten-ores, abs. 62.
——, ——, Castello di Bonvei, azurite-deposit, abs. 61.
Ivanoff, M. M., E. Ahnert, A. Khlaponin, P. Rippas, and P. Yavorovsky, gold-bearing regions of Siberia, abs. 90.

J.

Jackson, W. Morton, *liquid air and its use in rescue-apparatus*, 84.
Journals and transactions of societies, etc., in library, app. iii., lix.
Jovanovitch, Douchan, auriferous deposits of Servia, abs. 71.
Jumelle, H., and H. Perrier de la Bathie, cyperaceæ and the accumulation of alluvial gold, abs. 10.

K.

Kaolin-deposits, Germany, Saxony, Halle-an-der-Saale, abs. 52.
Kerner, F. von, tertiary coal-deposits of Ruda, Dalmatia, abs. 20.
Khlaponin, A., gold-bearing regions of Siberia, abs. 90.
Khlaponin, A., E. Ahnert, M. M. Ivanoff, P. Rippas, and P. Yavorovsky, gold-bearing regions of Siberia, abs. 90.
Kirkup, J. P., *reports on circumstances attending explosion at Wingate Grange colliery*, 156.
Kipkup, P., *experiments illustrative of inflammability of mixtures of coal-dust and air*, 76.
Kirkup, P., *reports on circumstances attending explosion at Wingate Grange colliery*, 154.
Korea, mineral resources, abs. 88.
Korsuchin, J., mineral resources of Chukchen Peninsula, southern Siberia, abs. 95.
Krasnopolsky, A., manganiferous and other ore-deposits of Nizhne-Tagilsk, Russia, abs. 71.
Krusch, P., recent bore-holes and sinkings in Rhenish-Westphalian coal-field, abs. 47.

L.

Lackner, Anton, pyritic deposits of Kazanesd, Hungary, abs. 24.
Lake- and bog-ores, formation, humus, abs. 11.
Lapland, Finnish, auriferous deposits, abs. 69.
——, graphite-deposits, abs. 69.
Laromiguière, Jules, coal-basins of Carmaux-Albi, France, abs. 34.
Laur, Francis, gold and silver in trias of French Lorraine, abs. 40.
Lawrence, Henry, *new apparatus for rescue-work in mines*, 150.
——, *sliding-trough conveyors*, 168.
Leach, C. C., *liquid air and its use in rescue-apparatus*, 127, 129, 130.
——, *reports on circumstances attending explosion at Wingate Grange colliery*, 156.
——, *treatment of dust in mines, above-ground and belowground*, 182, 183.
Lectures for colliery engineers, etc., brief syllabus, app. iii., lvi.
Legislation, mining, in Holland, abs. 1.
Leprince-Ringuet, Félix, underground temperatures in Pas-de-Calais, France, abs. 2.
Libert, Joseph, manganiferous iron-ores of Lienne, Belgium, abs. 33.
Library, list of transactions and journals of societies, etc., app. iii., lix.
Limestones, asphaltic, France, Gard, abs. 42.
Liquid air and its use in rescue-apparatus, 78, 124.
Lohest, M., H. Forir, and A. Habets, Campine coal-field, Belgium, abs. 30.
Lotti, B., metalliferous deposits of north-eastern Sicily, abs. 63.
Louis, Henry, *deposits in pit-fall at Tanfield Lea, Tantobie, County Durham*, 71.
——, *liquid air and its use in rescue-apparatus*, 126.
——, *valuation of mineral properties*, 63.
Lovisato, Domenico, tungsten-ores in Cagliari district, Sardinia, abs. 62.

M.

Machine-mining, practical problems, 37.
Magmatic segregation of iron-ores in granite, abs. 17.
Magnetic iron-ore, France, Lower Normandy, Diélette, abs. 39.
— pyrites, nickeliferous, Germany, Baden, Black Forest, abs. 53.
Maier, Ernst, gold-bearing regions of Siberia, abs. 92.
Malplat, M., sliding-trough conveyors, 166.—Discussion, 168.
Manchuria, southern, Fushun, coal-bearing beds, abs. 88.
Manganese-deposits, formation, manganiferous bog-ore, abs. 12.
Manganiferous bog-ore and formation of manganese-deposits, abs. 12.
— iron-ores, Belgium, Lienne, abs. 33.
— ore-deposits, Russia, Nizhne-Tagilsk, abs. 71.
Mann, Otto, pyrites-deposits of western Erzgebirge, Saxony, abs. 56.
Mariani, E., argentiferous galena of Cadlimo, Switzerland, abs. 83.
Marine bands, coal-measures, Belgium, Charleroi, abs. 28.
— —, — —, upper, Belgium, Mons, abs. 30.
— strata, carboniferous, Hungary, abs. 21.
Maurice, William, Rateau exhaust-steam-driven three-phase haulage plant.—Discussion, 71.
Mavor, Sam, practical problems of machine-mining.—Discussion, 37.
May, George, *appliance for automatically stopping and restarting mine-wagons*, 22.
Members, election, 18, 36, 69, 123, 147, 173.
—, list, app. iii., xvii.
Memoirs, Sir Lowthian Bell, Bart., 187.
—, John Daglish, 169.
—, George Henry Evans, app. iii., lxxxix.
Mercalli, G., earthquake of 1905 in Calabria, Italy, abs. 5.
Mercury ore-deposits, Servia, Avala hill, abs. 73.
Merivale, J. H., *appliance for automatically stopping and restarting mine-wagons*, 23.
—, death of John Daglish, 36.
—, *deposits in pit-fall at Tanfield Lea, Tantobie, County Durham*, 71.
—, evidence to Miners' Eight-hours Day Committee on behalf of The North of England Institute of Mining and Mechanical Engineers, app. iii., lxxxv.
Merivale, J. H., *experiments illustrative of inflammability of mixtures of coal-dust and air*, 77.
—, *liquid air and its use in rescue-apparatus*, 131.
—, *new apparatus for rescue-work in mines*, 149, 150.
—, *Rateau exhaust-steam-driven three-phase haulage plant*, 72.
—, *reports on circumstances attending explosion at Wingate Grange colliery*, 164.
—, *sinking through magnesian limestone and yellow sand by freezing-process at Dawdon colliery, Seaham Harbour, County Durham*, 122, 177.
—, *sliding-trough conveyors*, 168.
—, *treatment of dust in mines, above-ground and below-ground*, 181.
Metalliferous belt, Holzappel, Germany, Hesse-Nassau, abs. 56.
— deposits, France, Alsace, Val de Villé, abs. 41.
— ores, origin and age, abs. 14.
Meunier, Stanislas, genesis of pisolitic iron-ores, abs. 18.
Michael, R., *posidonia becheri* in Upper Silesian coal-measures, abs. 51.
Millosevich, F., azurite-deposit of Castello di Bonvei, Sardinia, abs. 61.
Mine-wagons, appliance for automatically stopping and restarting, 19.
Mineral properties, valuation, 45.
— resources, Asia Minor, abs. 84.
— —, Korea, abs. 88.
— —, Russian Empire, Siberia, eastern, Chukchen peninsula, abs. 95.
Miners' Eight-hours Day Committee, evidence of J. H. Merivale on behalf of The North of England Institute of Mining and Mechanical Engineers, app. iii., lxxxv.
Mining, machine-, practical problems, 37.
— legislation in Holland, abs. 1.
Monkwearmouth, C pit, 185.
Montessus de Ballore, F. de, seasonal distribution of earth-tremors, abs. 3.
Mountain, W. C., *experiments illustrative of inflammability of mixtures of coal-dust and air*, 76.
—, *Rateau exhaust-steam-driven three-phase haulage plant*, 71.

N.

Nicaragua, Masaya, earthquakes, 1906, abs. 9.
Nickeliferous magnetic pyrites, Germany, Baden, Black Forest, abs. 53.

Nicot, P., asphaltic limestones of Gard, France, abs. 42.
Norway, Finnish Lapland, auriferous deposits, abs. 69.
—, Lapland, graphite-deposits, abs. 69.
—, Traag, blende- and galena-deposits, abs. 65.
Noth, Julius, petroleum-bearing rocks of Komarnik-Mikova and Luh, Hungary, abs. 22.
Novarese, Vittorio, graphite-deposits in Piedmontese Alps, abs. 59.

O.

O'Donahue, T. A., valuation of mineral properties, 45.—Discussion, 63.
Officers, election, 6.
—, 1907-1908, app. iii., xv.
Oliver, Thomas, *liquid air and its use in rescue-apparatus*, 127, 129, 130.
Ore-deposits, Asia Minor, abs. 84.
— —, France, Alsace, Val de Villé, abs. 41.
— —, Germany, Baden, Black Forest, abs. 53.
— —, —, Bavaria, Fichtelgebirge, abs. 55.
— —, —, Hesse-Nassau, abs. 56.
— —, —, Saxony, western Erzgebirge, abs. 56.
— —, iron, formation and classification, abs. 16.
— —, Italy, Sardinia, Cagliari district, abs. 62.
— —, —, —, Castello di Bonvei, abs. 61.
— —, mercury, Servia, Avala hill, abs. 73.
— —, Norway, Traag, abs. 65.
— —, origin, diffusion-theory, abs. 15.
— —, Russia, Nizhne-Tagilsk, abs. 71.
Ore-deposits, Sicily, north-eastern, abs. 63.
— —, Spain, Almeria, abs. 75.
— —, —, Huelva, abs. 80.
— —, Sweden, northern, Gellivaara, abs. 68.
— —, —, —, Kiirunavaara, abs. 66, 68.
— —, Switzerland, Cadlimo, abs. 83.
— —, tungsten, Germany, Saxony, abs. 58.
Ores, bog-, manganiferous, and formation of manganese-deposits, abs. 12.
—, — and lake-, formation, humus, abs. 11.
—, iron-, France, Ardennes, derived from glauconite, abs. 38.
—, —, in granite, magmatic segregation, abs. 17.
—, —, magnetic, France, Lower Normandy, Diélette, abs. 39.
—, —, manganiferous, Belgium, Lienne, abs. 33.
—, —, pisolitic, genesis, abs. 18.
—, metalliferous, origin and age, abs. 14.
Ozokerite-deposits, Austria-Hungary, Galicia, Boryslaw, abs. 23.

P.

Palibin, J., coal-bearing beds of Fushun, southern Manchuria, abs. 88.
Palmer, Claude B., *appliance for automatically stopping and restarting mine-wagons*, 23.
—, *liquid air and its use in rescue-apparatus*, 93.
Patrons, list, app. iii., xvi.
Perrier de la Bathie, H., and H. Jumelle, cyperaceæ and the accumulation of alluvial gold, abs. 10.
Petroleum, stratigraphical conditions affecting occurrence, abs. 19.
Petroleum-bearing rocks, Austria-Hungary, Hungary, Komarnik-Mikova and Luh, abs. 22.
Petroleum-deposits, Austria-Hungary, Galicia, Boryslaw, abs. 23.
Phosphatic deposits, France, abs. 44.
Pieri, Gino, cutaneous infectivity of ankylostomiasis, abs. 1.
Pisolitic iron-ores, genesis, abs. 18.
Pit-fall at Tanfield Lea, Tantobie, County Durham, deposits in, 24, 70.
Pneumatogen: self-generating rescue-apparatus, compared with other types, 174.
Pelienov, B. K., coal-bearing beds in Kuznetsk district, Siberia, abs. 89.
Posidonia becheri in Upper Silesian coal-measures, abs. 51.
Practical problems of machine-mining, 37.
Preobrazhensky, P. I., and A. Gerasimoff, gold-bearing regions of Siberia, abs. 90.
Priemel, Kurt, brown-coal deposits of Upper Lausitz, Silesia, abs. 49.
Problems, practical, of machine-mining, 37.
Properties, mineral, valuation, 45.
Pütz, O., ore-deposits of province of Almeria, Spain, abs. 75.
Pyrites, nickeliferous magnetic, Germany, Baden, Black Forest, abs. 53.
Pyrites-deposits, Germany, Saxony, western Erzgebirge, abs. 56.
— —, Spain, Huelva, abs. 80.
Pyritic deposits, Austria-Hungary, Hungary, Kazanesd, abs. 24,

R.

Rateau exhaust-steam-driven three-phase haulage plant, 71.
Renier, Armand, flora of lower coal-measures of Bandour, Hainaut, abs. 29.
—, formation of Belgian coal-measures, abs. 26.
Representatives on council of The Institution of Mining Engineers, election, 11.
Rescue-apparatus, liquid air and its use in, 78, 124.
— —, pneumatogen, self-generating, compared with other types, 174.
Rescue-work in mines, new apparatus, 148.
Richardson, R., *liquid air and its use in rescue-apparatus*, 91.
Rippas, P., E. Ahnert, M. M. Ivanoff, A. Khlaponin, and P. Yavorovsky, gold-bearing regions of Siberia, abs. 90.
Robertson, J. R. M., *practical problems of machine-mining*, 39.
Rosberg, J. E., earthquake in Finland, 1902, abs. 6.
Ruegg, A. H., J. B. Atkinson, and R. Donald Bain, reports on circumstances attending explosion at Wingate Grange colliery.—Discussion, 151.
Russia, Finnish Lapland, auriferous deposits, abs. 69.
—, Lapland, graphite-deposits, abs. 69.
—, Nizhne-Tagilsk, manganiferous and other ore-deposits, abs. 71.
Russian Empire, Siberia, eastern, Chukchen peninsula, mineral resources, abs. 95.
— —, —, gold-bearing regions, abs. 90.
— —, —, Kuznetsk district, coal-bearing beds, abs. 89.

S.

St. Étienne coal-field, France, shear-planes, abs. 37.
Sapper, Karl, earthquakes of 1906 at Masaya, Nicaragua, abs. 9.
Scandinavia, Finnish Lapland, auriferous deposits, abs. 69.
—, Lapland, graphite-deposits, abs. 69.
Schmeisser, C., mineral resources of Asia Minor, abs. 84.
Schmidt, Albert, stanniferous deposits of Fichtelgebirge, Bavaria, abs. 55.
Seasonal distribution of earth-tremors, abs. 3.
Segregation, magmatic, of iron-ores in granite, abs. 17.
Self-generating rescue-apparatus, pneumatogen, compared with other types, 174.
Servia, auriferous deposits, abs. 71.
—, Avala hill, mercury ore-deposits, abs. 73.
Shear-planes, France, St. Étienne coal-field, abs. 37.
Sicily, north-eastern, metalliferous deposits, abs. 63.
Silver, France, Lorraine, abs. 40.
Simonis, Otto, liquid air and its use in rescue-apparatus, 78.—Discussion, 83, 124.
Sinking through magnesian limestone and yellow sand by freezing-process, Dawdon colliery, 95, 165, 175.
Sinkings, recent, Germany, Rhenish Prussia, Rhenish-Westphalian coal-field, abs. 47.
—, —, —, Westphalia, Rhenish-Westphalian coal-field, abs. 47.
Sliding-trough conveyors, 166.
Smythe, J. A., deposits in pit-fall at Tanfield Lea, Tantobie, County Durham, 24.—Discussion, 70.
South America, Chile, earthquake, 1906, abs. 7.
Spain, Almeria, ore-deposits, abs. 75.
—, Huelva, pyrites-deposits, abs. 80.
Stahl, A. F., stratigraphical conditions affecting occurrence of petroleum, abs. 19.
Stanniferous deposits, Germany, Bavaria, Fichtelgebirge, abs. 55.
Steavenson, A. L., Bowburn winning, 31.
—, death of John Daglish, 36.
—, *liquid air and its use in rescue-apparatus*, 124.
Steavenson, C. H., *treatment of dust in mines, aboveground and belowground*, 182.
Steffen, Hans, Chilian earthquake of August, 1906, abs. 7.
Steuer, A., asphalt-deposit at Mettenheim, Hesse, abs. 51.
Stibnite, auriferous, France, Britanny, Martigné, abs. 39.
Stopping and restarting mine-wagons, automatic appliance, 19.
Stratigraphical conditions affecting occurrence of petroleum, abs. 19.
Strzelecki, Percy, barometer, thermometer, etc., readings for year 1906, abs. 101.
Stuart, Donald M. D., awarded G. C. Greenwell medal, 17.
—, *reports on circumstances attending explosion at Wingate Grange colliery*, 151.

Students, election, 18, 37, 70, 124, 148, 174.
—, list, app. iii., liii.
Stutzer, O., auriferous stibnite of Martigné, Britanny, abs. 39.
—, formation of iron-ore deposits and their classification, abs. 16.
—, Gellivaara and Kiirunavaara iron-ores, northern Sweden, abs. 66, 68.
—, graphite-deposits in Lapland, abs. 69.
Subscribers, election, 148.
—, list, app. iii., liv.
Sutcliffe, R., *sinking through magnesian limestone and yellow sand by freezing-process at Dawdon colliery, Seaham Harbour, County Durham*, 176.
Sutcliffe, R., *treatment of dust in mines, aboveground and belowground*, 183.
Sweden, Finnish Lapland, auriferous deposits, abs. 69.
—, Lapland, graphite-deposits, abs. 69.
—, northern, Gellivaara, iron-ores, abs. 68.
—, —, Kiirunavaara, iron-ores, abs. 66, 68.
Switzerland, Cadlimo, argentiferous galena, abs. 83.
Syllabus, brief, of course of lectures for colliery engineers, etc., app. iii., lvi.

T.

Tanfield Lea, Tantobie, County Durham, deposits in pit-fall, 24, 70.
Temperatures, underground, Pas-de-Calais, France, abs. 2.
Termier, P., and G. Friedel, shear-planes in St. Étienne coal-field, France, abs. 37.
Tertiary coal-deposits, Austria-Hungary, Dalmatia, Ruda, abs. 20.
Thermometer, barometer, etc., readings, 1906, abs. 101.
Three-phase haulage plant, Rateau exhaust-steam-driven, 71.
Thwaite electro-barograph for mines, 29.
Tietze, O., phosphatic deposits of France, abs. 44.
Tin, Africa, Congo Free State, Katanga, abs. 97.
Transactions and journals of societies, etc., in library, app. iii., lix.
Trener, G. B., diffusion-theory of origin of ore-deposits, abs. 15.
Trough, sliding-, conveyors, 166.
Tungsten-ore deposits, Germany, Saxony, abs. 58.
— — —, Italy, Sardinia, Cagliari district, abs. 62.

U.

Underground temperatures, Pas-de-Calais, France, abs. 2.
Ungemach, —, metalliferous deposits of Val de Villé, Alsace, abs. 41.

V.

Valuation of mineral properties, 45.
Vogt, J. H. L., blende- and galena-deposits of Traag, Norway, abs. 65.
Vogt, J. H. L., magmatic segregation of iron-ores in granite, abs. 17.
—, manganiferous bog-ore and formation of manganese-deposits, abs. 12.

W.

Wagons, mine-, appliance for automatically stopping and restarting, 19.
Wardell, Stuart C., *liquid air and its use in rescue-apparatus*, 90.
Ware, R. G., awarded G. C. Greenwell medal, 17.
Weeks, J. G., *appliance for automatically stopping and restarting mine-wagons*, 22.
Weinschenk, E., niekeliferous magnetic pyrites of Black Forest, Baden, abs. 53.
Weiss, Paul, and Jules Bergeron, coal-field of French Lorraine, abs. 35.
Westermann, H., Aix-la-Chapelle coal-field, Germany, abs. 45.
Wetzig, Bruno, Huelva pyrites-deposits, Spain, abs. 80.
Widdas, Henry, and P. Phillips Bedson, experiments illustrative of inflammability of mixtures of coal-dust and air, 73.—Discussion, 75.
Wingate Grange colliery, explosion, 151.
Wolfram-ores, Austria-Hungary, Tyrol, south, abs. 25.

Wood, E. Seymour, sinking through magnesian limestone and yellow sand by freezing-process at Dawdon colliery, Seaham Harbour, County Durham, 95.—Discussion, 121, 165, 175.

Wood, E. Seymour, *treatment of dust in mines, aboveground and belowground*, 181.

Wüst, Ewald, kaolin-deposits of Halle-an-der-Saale, Saxony, abs. 52.

Y.

Yakovlev, N., manganiferous and other ore-deposits of Nizhne-Tagilsk, Russia, abs. 71.

Yavorovsky, P., E. Ahnert, M. M. Ivanoff, A. Khlaponin, and P. Rippas, gold-bearing regions of Siberia, abs. 90.

Z.

Zeiller, R., coal-field of French Lorraine, abs. 35.

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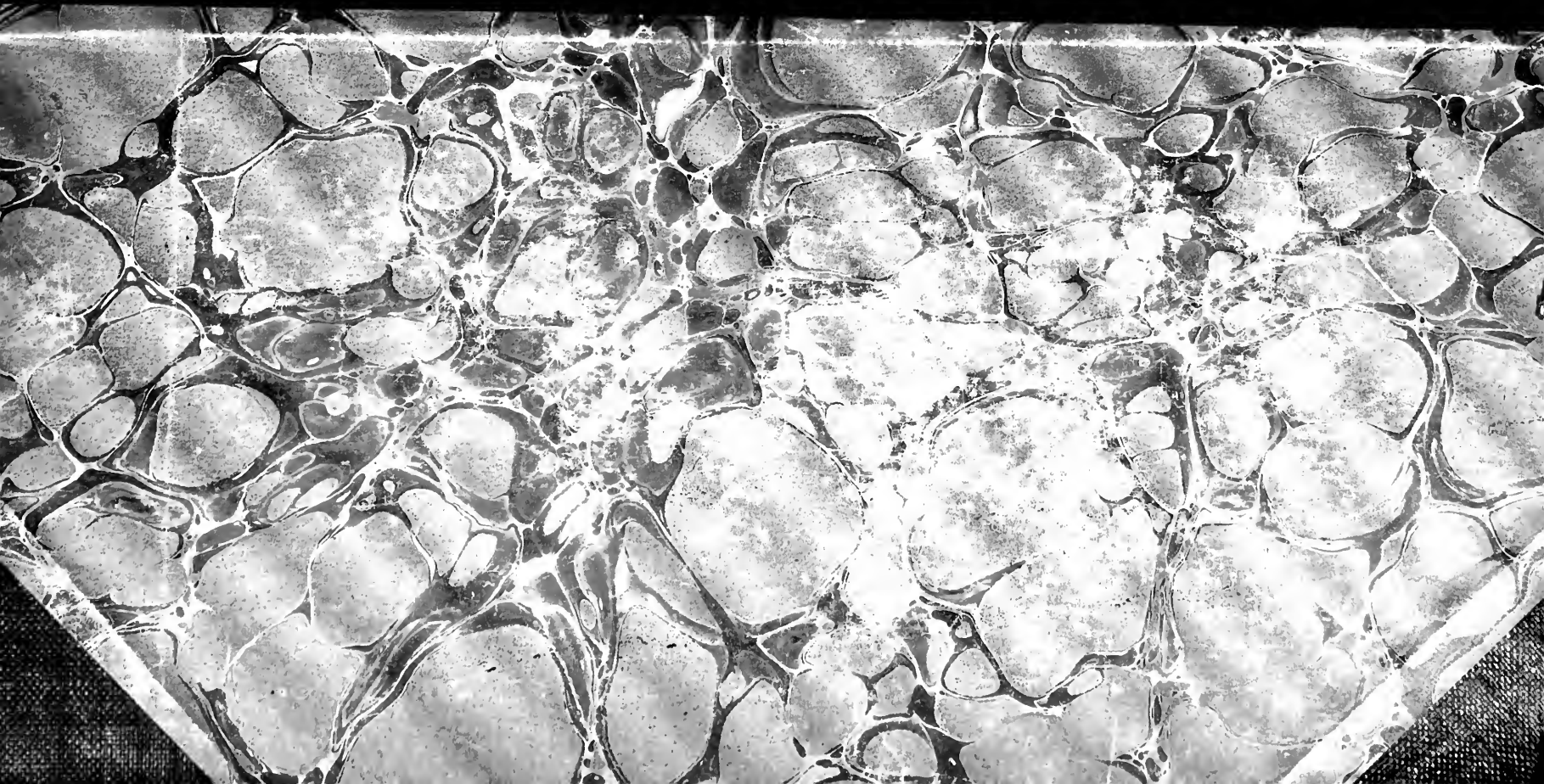
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